"EXPRESS MAIL" MAILING LABEL NO. EL659038400US
DATE OF DEPOSIT: January 25, 2001

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 C.F.R. 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231.

Mary E. Dionne
(TYPED OR PRINTED NAME OF PERSON MAILING PAPER OR FEE)

(SIGNATURE OF PERSON MAILING PAPER OR FEE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of:		)	
	M. Anthony Stone, et al.	)	
		)	Examiner: C. Goodman
on	HONEYCOMB REMOVAL	)	Art Unit: 3204
		)	
Serial No.:	08/327,744	)	
		)	
Filed:	October 24, 1994	)	(Our Docket No. 3309P-65)

Box **AF**
Commissioner of Patents
Washington, D.C. 20231

APPELLANTS' APPEAL BRIEF

SIR:

This appeal is taken from the final rejection dated August 15, 2000 in which Claim 1-8 were rejected under 35 U.S.C. § 103(a) as being unpatentable over McComas (U.S. Patent No. 5,167,721) in view of Shiembob, Ryan or Ackerman (U.S. Patent Nos. 4,433,845, 4,409,054, and 4,218,066 respectively), and, conversely, as being unpatentable over Shiembob, Ryan or Ackerman in view of McComas.

Real Party In Interest

The real party in interest in the above-referenced application is:

Pratt & Whitney Advanced Systems Technologies, Inc.

(formerly WATERJET SYSTEMS, INC.)

Huntsville, Alabama 35807

Related Appeals and Interferences

An Appeal Brief (Exhibit A) was filed October 23, 1998 in the above-referenced application. Subsequently, but before the Appeal Brief (Exhibit A) was considered by the Board, the Examiner reopened prosecution and set forth new grounds of rejection in a Final Office Action mailed August 15, 2000 (Exhibit B) to which the instant Appeal Brief is directed.

There are no other related appeals or interferences of which Appellants are aware regarding the above-referenced application.

Status of the Claims

Claims 1-8 are pending in this application. (A copy of the claims as finally rejected is attached as Exhibit C.) Claims 1-8 stand rejected by the Examiner under 35 U.S.C. § 103 and are presented to the Board in this Appeal.

Status of Amendments

With a Response to Office Action dated November 15, 2000, (Exhibit D), Applicant submitted a Declaration of Clifford V. Mitchell under 37 C.F.R. § 1.132. (Exhibit E). By Advisory Action dated December 1, 2000, (Exhibit F) the Examiner refused to enter the amendment on the grounds that the amendment contained new matter and confirmed the rejection of Claims 1-8 under 35 U.S.C. § 103.

As set forth in the previously submitted Appeal Brief dated October 23, 1998, (Exhibit A), an Amendment filed October 16, 1996 was entered in accordance with an Advisory Action issued November 19, 1996.

Summary of the Invention

With reference to Fig. 1 and page 7, line 29 - page 8, line 2 of the specification, the present invention is directed to the removal of honeycomb 1 and associated braze from

a substrate 3 using high pressure liquids. The honeycomb has a base and a ribbon direction 1a, and is typically fixed to the substrate by the braze.

The method comprises directing a pressurized liquid at an angle Ø of less than about 90° between the liquid and the substrate 3, e.g., the liquid travels in a direction that is *not* perpendicular to the surface of the substrate. The liquid is directed through at least one orifice of a nozzle 5 such that the liquid forms a liquid stream 7 upon exiting the nozzle. The liquid stream 7 is directed to strike the substrate 3 at the base of the honeycomb 1, and remove the honeycomb and associated braze from the substrate.

Various prior art methods exist for removing honeycomb from a substrate. Conventional methods are substantially limited to machining and grinding techniques, chemical immersion and de-brazing using heat. These methods often have undesirable results such as irreparable damage to the substrate, thus rendering the substrate unsuitable for re-use.

In contrast, the novel method of the present invention utilizes a pressurized liquid stream directed to strike the substrate at the honeycomb base, where the honeycomb joins the substrate. In this manner, the liquid stream removes the honeycomb and braze from the substrate without damaging the substrate, such that the substrate can be re-used.

Issues

1. Did the Examiner err in failing to acknowledge and comment upon the Declaration filed November 15, 2000?

2. Did the Examiner err in refusing to enter the Amendment filed on November 15, 2000 on the grounds that the phrase "metal honeycomb" was not earlier presented and lacks support in the specification?

3. Did the Examiner err in concluding that, under 35 U.S.C. § 103(a), Claims 1-8 are unpatentable over McComas (Exhibit G) in view of Shiembob, (Exhibit H), Ryan, (Exhibit I), or Ackerman, (Exhibit J), and, conversely, as being unpatentable over Shiembob, Ryan or Ackerman in view of McComas.

Grouping of the Claims

Claim 1 is independent; claims 2-8 depend directly upon claim 1.

Claims 1-8 stand or fall together.

Argument

I. The Examiner erred in omitting to acknowledge or comment upon the Inventor's Declaration filed November 15, 2000.

In response to the Final Office Action mailed August 15, 2000, (Exhibit B) in which Claims 1-8 were rejected under § 103(a), Applicant filed a Declaration under § 1.132, signed by Inventor Clifford Mitchell, (Exhibit E) in which evidence of undue experimentation and long felt need was presented to rebut the Examiner's finding of obviousness. (See Response to Office Action dated November 15, 2000, Exhibit D)

The Declaration was filed with a first reply after final rejection for the purpose of overcoming a new ground of rejection and was therefore timely filed in accordance with MPEP § 716.01(A).[1]

The Examiner, however, neither acknowledged nor commented upon the Declaration. (See Advisory Action issued December 1, 2000, Exhibit F) Applicant's representative discussed the Declaration at length with the Examiner by telephone on December 19, 2000[2], and, although the Examiner was not persuaded to allow the case, Applicant's representative understood that a new Advisory Action addressing the

---

[1] Affidavits and declarations submitted under 37 CFR § 1.132 and other evidence traversing rejections are considered timely if submitted ... (3) after final rejection and submitted (i) with a first reply after final rejection for the purpose of overcoming a new ground of rejection or requirement made in the final rejection ...

[2] No written summary of the December 19, 2000 telephone conference was received by the Applicant.

Declaration would be issued. To date, however, no such Advisory Action has been received by the Applicant.

Evidence traversing rejections must be considered by the examiner whenever present and failure to acknowledge or comment upon rebuttal evidence present by the Applicant is directly contrary to the Patent Office procedure and well settled case law.

> "All entered affidavits, declarations, and other evidence traversing rejections are acknowledged and commented upon by the examiner in the next succeeding action."

MPEP § 716.01(B).

Affidavits or declarations containing evidence of criticality or unexpected results, commercial success, long felt but unsolved needs, failure of others, skepticism of experts, etc. must be considered by the examiner in determining the issue of obviousness of claims for patentability under 35 U.S.C. § 103. See Stratoflex, Inc. v. Aeroquip Corp., 713 F.2d 1530, 1538, 218 USPQ 871,879 (Fed. Cir. 1983)

> "A determination under 35 U.S.C. § 103 should rest on all the evidence and should not be influenced by any earlier conclusion (citations omitted). Thus, once the applicant has presented rebuttal evidence, Office personnel should reconsider any initial obviousness determination in view of the entire record (citations omitted). Only then should any rejection be imposed in an Office action. The Office Action should clearly communicate the Office's findings and conclusions, articulating how the conclusions are supported by the findings." (emphasis added).

MPEP § 2144.08. III:

The evidence of undue experimentation and long felt need presented in the Declaration should have been acknowledged and considered by the Examiner. Even if the Examiner has established a *prima facie* case of obviousness, the Declaration provides strong rebuttal evidence that weighs in favor of patentability. Accordingly, Applicant requests that the Board reverse the Examiner's finding of obviousness and reverse the Examiner' s rejection of Claims 1-8. At a minimum, Applicant requests that the Board remand the case to the Examiner with direction to properly consider the Declaration.

II. The Examiner erred in concluding that the phrase "metal honeycomb" was not earlier presented and lacks support in the specification?

In the Advisory Action dated December 1, 2000, (Exhibit F) the Examiner refused to enter the amendment to independent claim 1, in which the noun 'honeycomb' was modified by the adjective 'metal'. The Examiner noted:

> *In Claim 1, the phrase "metal honeycomb" was not earlier presented and requires further consideration; thus raising new issues. Moreover, the disclosure as originally filed lacks support for "metal honeycomb". This is deemed new matter.*

The Examiner overlooked relevant language in the Application. During the telephone conference with the Examiner on December 19, 2000, Applicant's representative urged the Examiner to review the application, pointing out that the description of the honeycomb as 'metal' is indeed supported in the disclosure. See Application page 1, line 9 of the application:

> "The honeycomb structure which is commonly composed of metals such as HASTELLOY™ is typically formed with ribbon which is attached to the component with a braze generally comprised of metals such as nickel, chrome, and others, and various combinations thereof." (emphasis added).

Likewise, on Application, page 8, line 8:

> "The following example has been used to remove HASTELLOY-X honeycomb attached to an engine component segment, with an AMS 4777 (nickel-chrome) braze."

Based on the cited passages, the Examiner's conclusion that *"metal honeycomb" lacks support in the disclosure as originally filed" is* clearly erroneous.

With the proposed addition of the word 'metal' in independent claim 1 to describe honeycomb, Applicant was merely attempting to clarify that honeycomb is different from the coating materials discussed in the McComas patent, i.e., materials applied by either sintering powder or fibers, or by plasma spraying. It is precisely because honeycomb is a metal, with very different erosion characteristics from the coatings discussed in McComas, that one skilled in the art would not find the method disclosed in McComas obviously applicable to honeycomb removal.

3. The present invention is not *prima facie* obvious over the combination of McComas and either Shiembob, Ryan or Ackerman.

In the Final Office Action dated August 15, 2000, (Exhibit B, pg. 3) The Examiner rejected Claims 1-8 under 35 U.S.C. § 103(a) stating:

> *Although McComas lacks a honeycomb as the form of the coating, McComas does teach that the method encompasses removal of abradable seals which are used in gas turbine engines. Regarding the honeycomb, Shiembob, Ryan, and Ackerman all teach that a honeycomb, braze and substrate is a well known abradable seal in the art for gas turbine engines..... Thus, it would have been obvious to the ordinary artisan at the time of the instant invention to provide the method of McComas with the honeycomb as taught by either Shiembob, Ryan or Ackerman in order to facilitate the removal of the same from the substrate during maintenance, since as noted above, the honeycomb is another form of an abradable seal that is a "coating" for which McComas method is to be applied.*

The teaching of McComas U.S. Patent No. 5,167,721, LIQUID JET REMOVAL OF PLASMA SPRAYED AND SINTERED, (Exhibit G) is discussed at length in the previously filed Appeal Brief (Exhibit A). In sum, McComas discloses a method for removal of coating materials, and in particular the removal of abradable, wear resistant, and thermal barrier coating materials which have been applied by either sintering powders or fibers, or by plasma spraying, utilizing liquid jet erosion.

In Ryan, U.S. Patent No. 4,409,054, METHOD FOR APPLYING ABRADABLE MATERIAL TO A HONEYCOMB STRUCTURE AND THE PRODUCT THEREOF, (Exhibit I) honeycomb structures, such as those used in turbine engine abradable seals, are provided with a uniform density filling of a suitable abradable material. The abradable material is prepared as a tape preform using an organic binder. The preform is forced into the honeycomb using a rubber tool.

Ackerman, U.S. Patent No. 4,218,066 for ROTARY SEAL, (Exhibit J) discloses an apparatus for impeding the leakage of a gaseous medium between rotating and stationary components of a gas turbine engine. Wide channel sealing techniques are discussed in combination with honeycomb facing materials.

Shiembob, U.S. Patent No. 4,433,845 for INSULATED HONEYCOMB SEAL, (Exhibit H) discloses the manufacture of a seal for a row of turbine blades in which the seal is a honeycomb seal and a layer of insulation is positioned in the cells of the

honeycomb by flame spraying. A process for accomplishing the deposition of the insulation is also described.

With the combination of McComas, Ryan, Ackerman and/or Shiembob, the Examiner failed to establish a *prima facie* case of obviousness in accordance with MPEP § 2142 and 2143.

> "To establish a prima facie case of obviousness, three basic criteria must be met.
>
> First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings.
>
> Second, there must be a reasonable expectation of success.
>
> Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success, must both be found in the prior art, and not based on applicant's disclosure, (citations omitted)".

MPEP § 2142 and 2143.

1. <u>There is no suggestion or motivation in the references or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings.</u>

Ackerman issued on August 19, 1980; Ryan on October 11, 1983; and Shiembob on February 28, 1984. McComas was filed December 5, 1991. McComas, Ryan, Shiembob and Ackerman are all owned by United Technologies Corporation.

As the Examiner acknowledges[3], by the time the McComas patent was filed in 1991, the use of honeycomb was well known to those skilled in the art at United Technologies Corporation. Yet, as the Examiner also acknowledges,[4] McComas does not teach that the claimed method can be used with honeycomb.

---

[3] *"Regarding the honeycomb, Shiembob, Ryan, and Ackerman all teach that a honeycomb, braze, and substrate is a well know abradable seal in the art for gas turbine engines...."* Final Office Action dated August 15, 2000 pg. 3 (Exhibit B)

[4] *"Although McComas lacks a honeycomb as the form of the coating....."* Ibid.

Contrary to the Examiner's statement that *"the honeycomb is another form of an abradable seal that is a "coating" for which McComas method is to be applied"*,[5] the lack of any reference whatsoever to honeycomb in the McComas patent, points to the conclusion that it would not have been obvious - even to those highly skilled in the art at United Technologies Corporation - to apply the McComas method to honeycomb.

The teaching of McComas is directed to "the removal of coating materials, and specifically to the removal of abradable, wear resistant, and thermal barrier coating materials which have been applied by either sintering powder or fibers, or by plasma spraying, utilizing liquid jet erosion." See Technical Field McComas, Col. 1, line 10. Honeycomb is not such a coating, as was well known by those skilled in the art at United Technologies Corporation.

In short, there is simply no teaching in McComas to apply the disclosed method to honeycomb or any other type of material except for "sprayed and sintered coatings whose cohesive strength is significantly less than that of the substrate." McComas Col. 2, line 43. Likewise there is no teaching or suggestion in either Shiembob, Ryan or Ackerman relevant to honeycomb removal. The Examiner indirectly makes Applicant's point: *".. McComas lacks a honeycomb as the form of the coating..."* (Final Office Action dated August 15, 2000, Exhibit B, pg. 3) and *"None of these references [Shiembob, Ryan or Ackerman] teach the method of removal of the honeycomb and braze from the substrate."* (Final Office Action dated Aug. 15, 2000, Exhibit B, pg. 4)

"To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." Ex Parte Clapp, 227 USPQ 972, 973 (Bd. Pat. App. & Int. 1985) See also In re Fine, 837 F.2d 1071, 5 USPQ2d 1956 (Fed. Cir. 1988) and In re Jones, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992)

---

[5] Final Office Action dated August 15, 2000, page 4.

2. There was no reasonable expectation of success.

As indicated in the Declaration of the Inventor, (Exhibit E) honeycomb has very different erosion characteristics from the sprayed and sintered coatings discussed in McComas.

Given (1) that McComas makes no reference to honeycomb, even though honeycomb was well known as an abradable seal at the time McComas was filed, and given (2) the inventor's unchallenged statement in the Declaration that

> "The methods typically employed to remove sprayed and sintered coatings such as plasma, rubber, fibermetal and epoxy materials from base materials such as nickel, steel, titanium, and aluminum are not generally applicable to honeycomb removal." (Declaration ¶ 2, Exhibit E)

the prior art and the general understanding at the time the present application was filed, suggest that those skilled in the art would not have predicted that the method disclosed in McComas was applicable to the removal of honeycomb materials disclosed in Ackerman, Ryan and Shiembob.

Obviousness does not require absolute predictability, however, at least some degree of predictability is required. In re Rinehart, 531 F.2d 1048, 189 USPQ 143 (CCPA 1976), Amgen, Inc. v. Chugai Pharmaceutical Co., 927, F.2d 1200, 1207-08, 18 USPQ2d 1016, 1022-23 (Fed. Cir.), cert denied, 502 U.S. 856 (1991).

3. The prior art references do not teach or suggest all of the claim limitations.

To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974) "All words in a claim must be considered in judging the patentability of that claim against the prior art. " In re Wilson, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970)

In the present application the references do not teach or suggest all of the claim limitations. No combination of references teach or suggest positioning the pressurized

liquid to strike the substrate at the base of the honeycomb as in Claim 1 of the present invention.

Claim 1 of the present application provides:

> A method for removing honeycomb and braze from a substrate, said honeycomb having a base and a ribbon direction, comprising: directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate, through at lease one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle, *the liquid stream striking the substrate at the base of the honeycomb*, thereby removing the honeycomb and braze from the substrate, whereby the substrate may be reused, *(emphasis added)*.

The Examiner is mistaken in asserting that McComas *"teaches a method of removing a coating 1 and bond coating 2 that is an abradable seal from a substrate comprising all the method steps claimed..... including the inherent step of having the liquid stream striking the substrate at the base of the coating, since inter alia, this striking position is the obvious position that facilitates simultaneous removal of the coating and bond coating from the substrate...."* See Final Office Action dated August 15, 2000, page 4, (Exhibit B).

To the contrary, McComas does not teach simultaneous removal of the coating and bond coating by having the liquid strike at the substrate at the base of the coating. McComas teaches sequential removal of first the top coating, and then the bond coating. See McComas Independent Claim 1, step d: "causing the liquid to strike the top coat, wherein the liquid striking the top coat causes top coat erosion until the bond coat is exposed."

As illustrated in McComas, Fig. 1, the liquid stream 5 is directed towards and impinges on the *topmost, exposed surface* of the coating. Accordingly, McComas teaches away from the invention as defined in claim 1, in which a liquid stream strikes *the substrate* at the base of the honeycomb.

Neither Shiembob, Ryan or Ackerman make any reference whatsoever to removing honeycomb from a substrate by any process; let alone a process in which a

"*... liquid stream strike[s] the substrate at the base of the honeycomb*" as claimed in the present application.

For at least the forgoing reasons, the Examiner's conclusion that, based on the cited prior art, "*it would have been obvious to the ordinary artisan at the time of the instant invention to apply the liquid removal method of McComas to the abradable honeycomb seals of either Shiembob, Ryan or Ackerman in order to facilitate easy removal of the honeycomb and braze without damaging the substrate.*[6]" is erroneous even without considering the rebuttal evidence provided in the Declaration.

Finally, if the Examiner's rejection under 35 U.S.C § 103 was based in part on the Examiner's personal knowledge, the Examiner failed to provide an Affidavit or other evidence per MPEP § 2144.03[7], as requested by Applicant (See Response to Office Action Exhibit D, pg. 5).

Conclusion

In view of the foregoing, Appellants request that the Board reverse the Examiner's rejection of claim 1. Since claims 2-8 depend from claim 1 and include all of the limitations of this claim, claims 2-8 are patentable over the McComas and reference for at least the same reasons discussed above in connection with claim 1. Accordingly, Appellants also request that the Board reverse the Examiner's rejection of dependent claims 2-8.

---

[6] See Final Office Action Dated August 15, 2000, Exhibit B pg. 4

[7] "When a rejection is based on facts within the personal knowledge of the examiner, the data should be stated as specifically as possible, and the facts must be supported, when called for by the applicant, by an affidavit from the examiner. Such an affidavit is subject to contradiction or explanation by the affidavit of the applicant and other persons." MPEP § 2144.03

The fee of $310.00 required under 37 C.F.R. §1.17(c) for submission of this Appeal Brief is enclosed. Please charge any deficiency in fee associated with the Petition and Appeal Brief to our Deposit Account No. 13-0235.

Applicants' Appeal Brief is being filed in triplicate.

Favorable consideration is respectfully requested.

Respectfully submitted,

By _____
Susan C. Oygard, Esq.
Attorney for Applicants
Registration No. 42,969

McCORMICK, PAULDING & HUBER LLP
CityPlace II
185 Asylum Street
Hartford, Connecticut 06103-4102
(860) 549-5290

"EXPRESS MAIL" MAILING LABEL NO. EM11213805US
DATE OF DEPOSIT October 23, 1998
I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 C.F.R. 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO: Box DAC, ASSISTANT COMMISSIONER FOR PATENTS, WASHINGTON, D.C. 20231,

PATRICIA A. KANE
(TYPED NAME OF PERSON MAILING PAPER OR FEE)

Patricia A. Kane
(SIGNATURE OF PERSON MAILING PAPER OR FEE)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the application of:	)	
	)	
M. Anthony Stone, et al	)	Examiner: GOODMAN, C.
	)	Art Unit: 3204
For: HONEYCOMB REMOVAL	)	
	)	
Serial No.: 08/327,744	)	
	)	(Our File No. 3309P-65)
Filed: October 24, 1994	)	

Springfield, MA, October 23, 1998

Box DAC
ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

Dear Sir:

APPELLANTS' APPEAL BRIEF

This appeal is taken from the final rejection dated June 10, 1996 in which, among other issues, claims 1-8 were rejected under 35 U.S.C. § 103 as being unpatentable over U.S. Pat. No. 5,167,721 to McComas and EP 207,059 to Peters.

This Brief accompanies a Petition To Revive this application. A Notice of Abandonment (Paper No. 14) issued on June 10, 1997, and a copy is attached as Exhibit A.

Real Party In Interest

The real party in interest in the above-referenced application is:

WATERJET SYSTEMS, INC.
Huntsville, Alabama 35807

Related Appeals and Interferences

There are no related appeals and interferences of which Appellants are aware regarding the above-referenced application.

Status of the Claims

Claims 1-8 are pending in this application. (A copy of the claims as finally rejected is attached as Exhibit B.) Claims 1-8 stand rejected by the Examiner under 35 U.S.C. § 103 and are presented to the Board in this Appeal.

Status of Amendments

An Amendment, Two Month Extension of Time and Notice of Appeal were filed on October 16, 1996 in response to the Final Office Action dated June 10, 1996. As a result of the Amendment, the objection in ¶¶ 4 and 5 of the Action to the specification and rejection of claims 1-8 under 35 U.S.C. § 112, first paragraph were withdrawn by the Examiner, as was an objection to the specification under 37 C.F.R. § 1.84.

An Advisory Action (Paper No. 13) issued on November 19, 1996 confirming that objection and rejection under 35 U.S.C. § 112, first paragraph were overcome, and the October 16, 1996 Amendment would be entered upon filing this appeal. The sole remaining objection is of claims 1-8 under 35 U.S.C. § 103.

Summary of the Invention

With reference to Fig. 1 and page 7, line 29 - page 8, line 2 of the specification, the present invention is directed to the removal of honeycomb 1 and associated braze from a substrate 3 using high pressure liquids. The honeycomb has a base and a ribbon direction 1a, and is typically fixed to the substrate by the braze.

The method comprises directing a pressurized liquid at an angle Ø of less than about 90° between the liquid and the substrate 3, e.g., the liquid travels in a direction that is *not* perpendicular to the surface of the substrate. The liquid is directed through at least one orifice of a nozzle 5 such that the liquid forms a liquid stream 7 upon exiting the nozzle. The liquid stream 7 is directed to strike the substrate 3 at the base of the honeycomb 1, and remove the honeycomb and associated braze from the substrate.

Various prior art methods exist for removing honeycomb from a substrate. Conventional methods are substantially limited to machining and grinding techniques, chemical immersion and debrazing using heat. These methods often have undesirable results such as irreparable damage to the substrate, thus rendering the substrate unsuitable for reuse.

In contrast, the novel method of the present invention utilizes a pressurized liquid stream directed to strike the substrate at the honeycomb base, where the honeycomb joins the substrate. In this manner, the liquid stream removes the honeycomb and braze from the substrate without damaging the substrate, such that the substrate can be reused.

Issues

The issue to be resolved is whether claims 1-8 are patentable over the combination of the McComas '721 and Peters '069 patents.

Grouping of the Claims

Claim 1 is independent; claims 2-8 depend directly upon claim 1. Claims 1-8 stand or fall together.

Argument

I. Claims 1-8 Are Patentable Over the Combined McComas and Peters Patents.

The combination of the McComas and Peters patents relied on by the Examiner in rejecting claims 1-8 under § 103 fail to teach or even suggest a method of removing honeycomb in which a liquid stream is directed to strike the substrate at the base of the honeycomb.

McComas merely teaches the erosion of plasma sprayed and sintered coating materials, in which a liquid jet impinges on the uppermost surface of the coating and erodes the coating until an underlying substrate or bond coating is exposed.

In McComas, a bond coat 2 is typically applied to the substrate prior to application of the coating material 1, and the coating material is then applied onto the bond coat. As illustrated in Fig. 1, discussed at col. 3, lines 23-47 and set forth in step (d) of claim 1, McComas uses a liquid stream 5 which is directed at and impinges on the coating material, and eventually erodes the coating material away until the underlying bond coat 2 or the substrate is exposed.

The liquid stream 5 is directed towards and impinges on the *topmost, exposed surface* of the coating. Accordingly, McComas teaches away from the invention as defined in claim 1, in which a liquid stream strikes *the substrate* at the base of the honeycomb.

Peters merely teaches severing sheet material, i.e., cutting completely through a multi-layer work piece 7 using cutting jets 31, 32 positioned on opposing sides of the workpiece, and is not at all concerned with the removal of the honeycomb from a substrate. (A copy of an English-language translation of Peters is attached as Exhibit C). The jets merely function as cutting blades for severing the work piece. The work piece 7 is a sheet of honeycomb material 73 which is *covered on both sides* by covering layers 71, 72. The jets impinge on both covering layers 71, 72 at angles a, b, and *cut completely through the covering layers and the honeycomb structure* 73, with the jets converging within the honeycomb structure.

Neither reference teaches or suggests the removal of honeycomb from a substrate, let alone directing a liquid jet to strike the *substrate at the base of the honeycomb* to remove the honeycomb from the substrate without damaging the substrate. Accordingly, Appellants request that the Board reverse the § 103 rejection issued by the Examiner.

A. Claim 1 of the Present Invention.

As discussed above, claim 1 is directed to a method of removing honeycomb and braze from a substrate using high pressure liquids. The honeycomb has a base and a ribbon direction.

The method comprises directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate. The liquid is directed through at least one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle. The stream is directed to strike the substrate at the base of the

honeycomb, and thus removes the braze and honeycomb from the substrate such that the substrate may be reused.

As also discussed above, the claimed method removes the honeycomb and associated braze from the substrate, but without damaging the substrate. Moreover, the claimed method is flexible enough to process out of round parts without damage to the parts, and, where water or other non-toxic liquids are employed as the liquid, is environmentally sound.

B. <u>The Examiner's Rejection of Claims 1-8</u>.

In ¶¶ 6 and 7 of the Final Office Action, the Examiner asserts that McComas teaches stripping a layer of material from a substrate, and that Peters teaches cutting honeycomb material using a water jet. The Examiner then argues that it would have been obvious "to remove honeycomb and braze from a substrate using a water jet to facilitate ease of removal," and rejects claims 1-8.

As the Examiner concedes in ¶5 of the first Office Action (Paper No. 4) Peters does not teach or suggest "positioning the pressurized liquid [to strike the substrate] at the base of the honeycomb." The Examiner cannot now assert that *either* reference teaches or suggests directing a pressurized liquid through a nozzle, with the resultant liquid stream "striking the substrate at the base of the honeycomb" to remove the honeycomb from the substrate, as set forth in claim 1.

Appellants submit that the Examiner's rejection of claims 1-8 is not supported by the teachings of the McComas '721 and Peters '069 patents.

C. The McComas '721 and Peters '069 Patents Do Not Support the Examiner's Rejection of Claims 1-8 under § 103.

The Examiner asserts that the combination of the McComas and Peters references renders the present invention obvious. McComas teaches the removal *by erosion* of coating materials such as abradable, wear resistant and thermal barrier coating materials that have been applied either by sintering or plasma spraying.

Peters is directed to cutting completely through a flat material, such as a honeycomb sheet, using two liquid jets positioned on opposite sides of the sheet. Neither reference is directed to the removal of honeycomb and associated braze from a substrate, as set forth in present independent claim 1. Neither reference teaches or suggests directing a liquid stream to strike the substrate at the base of the honeycomb to remove the honeycomb from the substrate, as set forth in present independent claim 1. Accordingly, Applicants submit that the rejection cannot stand.

1. The Combination of the McComas '721 and Peters '069 Patents is Not Appropriate.

There is no teaching, suggestion or motivation for combining the McComas '721 and Peters '069 Patents.

McComas teaches the removal *by erosion* of coating materials. The liquid stream 5 is directed towards and impinges on the *topmost, exposed surface* of the coating until the coating and bond coat is eroded away, thus exposing the underlying substrate. McComas does not relate to the removal of honeycomb material from a substrate, and does not teach or suggest directing the jet at the base of the coating, let alone the base of a honeycomb structure.

Peters teaches severing sheet material that is covered on both sides by a covering layers using cutting jets 31, 32 positioned on opposing sides of the work-piece. Peters fails to teach or suggest a honeycomb material fixed to a "substrate", and accordingly there is no honeycomb "base" at which a cutting jet 31, 32 can be directed. Peters teaches that each jet 31 or 32 impinges on the side of covering layer 71, 72 opposite the honeycomb structure, and cuts entirely through the covering layer *and also the* associated honeycomb. There is simply no teaching, suggestion or motivation of removing the honeycomb structure 73 from either covering layer 71, 72, as is done using the present invention.

Peters' disclosure is limited to using liquid streams as cutting implements, e.g., shears for cutting entirely through sheet material. See, e.g., page 1 last line - page 2, line 2 of the attached translation, Exhibit B. As discussed above and as the Examiner concedes, Paper No. 4, Peters does not teach or suggest "positioning the pressurized liquid [to strike the substrate] at the base of the honeycomb." By teaching that the cutting jets 31, 32 strike the covering layers on the side of the covering layers *opposite the honeycomb*, and cut through the covering layers *and* the honeycomb material, Peters teaches away from the invention, in which a liquid stream strikes *the substrate at the base of the honeycomb* to remove the honeycomb from the substrate without damaging the substrate.

Moreover, Peters requires the use of opposing cutting jets on opposing sides of the material being cut in order to function in the intended manner. Peters does not teach or suggest that use of only a single jet is of any utility. As discussed at page 4, lines 19-24 of Peters, by using two generally opposing jets so that the jets converge within the material being cut, the energy of one jet generally cancels the energy of the other jet. Peters would not function in this intended manner in the event that a single jet were employed on only one side of the work piece 7. While Peters might function in some manner with only a single jet, the Peters jet still

would not be directed to strike a covering layer or "substrate" at the "base of the honeycomb" *to remove the honeycomb structure from the covering layer*, and thus cannot be used to render the present invention obvious.

In sum, McComas relates to the removal *by erosion* of coating materials applied either by sintering or plasma spraying, and uses a liquid jet which *impinges on the top surface of a coating* to erode the coating and underlying bond coat from the substrate. Peters is directed to cutting completely through a work piece, and uses a pair of opposing cutting jets which are positioned on opposite sides of a work piece and *strike the covering layers on the sides of the layers opposite the honeycomb structure*. Peters does not relate at all to the removal by erosion of coating materials. Neither McComas nor Peters teaches or suggests directing a liquid stream to strike a substrate at the "base of the honeycomb" to remove the honeycomb and associated braze from the substrate, and thus cannot be used to render the present invention obvious. Apart from the use of liquid jets, there is no teaching, suggestion or motivation for combining McComas and Peters. Where, as here, the prior art fails to teach or suggest the combination proposed by the Examiner, the combination of McComas and Peters is inappropriate and the rejection under § 103 (a) cannot be maintained. See, e.g., Ex Parte Levengood, 28 USPQ2d 1300, 1302 (T.T.A.B. 1993); and In re Fine, 5 U.S.P.Q. 2d 1596, 1598-99 (Fed. Cir. 1988).

2. **The Combination of the McComas '721 and Peters '069 Patents Fails to Support the Rejection Under § 103.**

Even if the combination of the McComas '721 and Peters '069 patents is appropriate, the combination fails to teach or suggest significant aspects of the claimed invention. The combination of McComas and Peters would still fail to teach or suggest directing a liquid stream to strike the substrate at the base of the honeycomb material to remove the honeycomb material and associated braze without damaging the substrate.

Turning to col. 3, lines 23-42 of McComas, a liquid stream 5 is directed towards and impinges on the *top* of the coating. Peters uses cutting jets 31,32 positioned on both sides of a work piece to cut entirely through the covering layers 71,72 and the honeycomb structure 73. The combination of McComas and Peters merely teaches the use of jets positioned on either side of a workpiece to erode a covering layer, or cut entirely through the work piece.

The combination of the McComas and Peters patents not only fails to teach or suggest the use of a liquid stream for removing honeycomb material and associated braze from a substrate, but also fails to teach or suggest that a liquid stream is directed to strike the substrate at the base of the honeycomb. Where the proposed combination fails to teach or suggest the claimed invention, the rejection under § 103 (a) cannot be maintained. See, e.g., In re Fine, 5 U.S.P.Q. 2d at 1600.

In view of the foregoing, Appellants request that the Board reverse the Examiner's rejection of claim 1. Since claims 2-8 depend from claim 1 and include all of the limitations of this claim, claims 2-8 are patentable over the McComas and reference for at least the same reasons discussed above in connection with claim 1. Accordingly, Appellants also request that the Board reverse the Examiner's rejection of dependent claims 2-8.

Previously submitted was an Appeal Brief, dated December 8, 1997, with check No. 22862 in the amount of $310 therefor. Applicants' are resubmitting, in triplicate, the Appeal Brief with exhibits, signed by an attorney of record and dated October 23, 1998. Applicants are submitting concurrently a Renewed Petition Under 37 CFR 1.137(b) in response to the Decision to Dismiss, dated September 23, 1988 (Paper No. 19).

Should an additional fee be necessary, please charge our Deposit Account No. 13-0235.

Favorable consideration is respectfully requested. The office is invited to contact Applicants' undersigned representative in the event that there are any questions.

Respectfully submitted,

By: Susan C. Oygard
Susan C. Oygard
Registration No. 42,969
Attorney for Applicants

McCORMICK, PAULDING & HUBER LLP
CityPlace II
185 Asylum Street
Hartford, Connecticut 06103-4102
Tel.: (860) 549-5290
Fax.: (860) 527-0464

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/327,744	10/24/94	STONE M	3309P-65

EXAMINER	
GOODMAN, C	
ART UNIT	**PAPER NUMBER**
3724	25

DATE MAILED: 08/15/00

GM12/0815

J. KEVIN GROGAN
MCCORMICK, PAULDING & HUBER, LLP
CITY PLACE II
185 ASYLUM STREET
HARTFORD CT 06103-4102

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

DOCKET JKG
FILE 3309P-65
FOR Lonz 10/15/00
DATE 8/22/00 BY

EXHIBIT
B

Office Action Summary	Application No.	Applicant(s)	
	08/327,744	STONE ET AL.	
	Examiner	Art Unit	
	Charles Goodman	3724	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).

Status

1)☒ Responsive to communication(s) filed on *23 October 1998* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-8* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-8* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are objected to by the Examiner.

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

a)☐ All b)☐ Some * c)☐ None of the CERTIFIED copies of the priority documents have been:

1.☐ received.

2.☐ received in Application No. (Series Code / Serial Number) _____ .

3.☐ received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. & 119(e).

Attachment(s)

15) ☐ Notice of References Cited (PTO-892)
16) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
17) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
18) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
19) ☐ Notice of Informal Patent Application (PTO-152)
20) ☐ Other: .

DETAILED ACTION

1. In view of the Appeal Brief filed on October 23, 1998, PROSECUTION IS HEREBY REOPENED. New grounds of rejection are set forth below.

To avoid abandonment of the application, appellant must exercise one of the following two options:

(a) file a reply under 37 CFR 1.111 (if this Office action is non-final) or a reply under 37 CFR 1.113 (if this Office action is final); or,

(b) request reinstatement of the appeal.

If reinstatement of the appeal is requested, such request must be accompanied by a supplemental appeal brief, but no new amendments, affidavits (37 CFR 1.130, 1.131 or 1.132) or other evidence are permitted. See 37 CFR 1.193(b)(2).

2. The After Final Amendment filed on October 22, 1996 has been entered, since this amendment has been approved entry for Appeal purposes in the Advisory Action, Paper No. 13.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any

evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over McComas in view of Shiembob, Ryan, or Ackerman.

McComas discloses the invention substantially as claimed including the inherent step of having the liquid stream striking the substrate at the base of the coating 1 (analogous to the claimed honeycomb) due to, *inter alia*, the relative motion between the component and the liquid stream 5 and the fact that McComas removes both the coating and the bond coating 2 (analogous to the claimed braze) *simultaneously*. See Figs. 1-1A, c. 1, l. 19 - c. 3, l. 66. Although McComas lacks a honeycomb as the form of the coating, McComas does teach that the method encompasses removal of *abradable seals* which are used in gas turbine engines. See *Id.*, c. 1, ll. 19-25. Regarding the honeycomb, Shiembob, Ryan, and Ackerman all teach that a honeycomb, braze, and substrate is a well known abradable seal in the art for gas turbine engines. More specifically, Shiembob teaches an insulated honeycomb seal for gas turbine engines comprising a honeycomb 2 that is inherently brazed onto a substrate 18. See whole patent. Ryan teaches another abradable seal for gas turbine engines comprising a honeycomb 2 brazed onto a substrate 1. See whole patent. Ackerman teaches a further example of an abradable seal comprising a honeycomb 28 which is inherently brazed onto a substrate (not designated by reference but see Fig. 1). See whole patent. Thus, it would have been obvious to the ordinary artisan at the time of the instant invention to provide the method of McComas with the honeycomb as taught by

either Shiembob, Ryan, or Ackerman in order to facilitate the removal of the same from the substrate during maintenance, since as noted above, the honeycomb is another form of an abradable seal that is a "coating" for which McComas method is to be applied.

6. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Shiembob, Ryan, or Ackerman in view of McComas.

Shiembob, Ryan, or Ackerman all disclose various forms of abradable seals for gas turbine engine comprising a honeycomb, braze, and substrate structure. See *Id.* However, none of these references teach the method of removal of the honeycomb and braze from the substrate. In that regard, McComas teaches that it is common practice in the art to perform routine engine maintenance which frequently requires removal of coatings in the abradable seals. See *Id.*, c. 1, ll. 60-67. McComas specifically teaches a method of removing a coating 1 and bond coating 2 that is an abradable seal from a substrate comprising all the method steps claimed, i.e. flow, pressure, and angle of the liquid stream 5, including the inherent step of having the liquid stream striking the substrate at the base of the coating, since, *inter alia*, this striking position is the obvious position that facilitates simultaneous removal of the coating and bond coating from the substrate, this method facilitating easy removal without damaging the substrate. Thus, it would have been obvious to the ordinary artisan at the time of the instant invention to apply the liquid removal method of McComas to the abradable honeycomb seals of either Shiembob, Ryan, or Ackerman in order to facilitate easy removal of the honeycomb and braze without damaging the substrate whenever maintenance requires the same, since as taught by McComas, abradable seals is just another form of coating that is subject to removal of the same during maintenance.

Response to Arguments

7. Applicant's arguments with respect to claims 1-8 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

8. Applicant's submission of an information disclosure statement under 37 CFR 1.97(c) with the fee set forth in 37 CFR 1.17(p) on May 21, 1996 (Paper No. 9) prompted the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL.** See MPEP § 609(B)(2)(i). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

9. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Charles Goodman whose telephone number is (703) 308-0501. The examiner can normally be reached on Monday-Thursday between 7:30 AM to 6:00 PM

EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Rinaldi Rada, can be reached on (703) 308-2187. The fax phone number for this Group is (703) 305-3579.

Communications via Internet e-mail regarding this application, other than those under 35 U.S.C. 132 or which otherwise require a signature, may be used by the applicant and should be addressed to [**rinaldi.rada@uspto.gov**].

All Internet e-mail communications will be made of record in the application file. PTO employees do not engage in Internet communications where there exists a possibility that sensitive information could be identified or exchanged unless the record includes a properly signed express waiver of the confidentiality requirements of 35 U.S.C. 122. This is more clearly set forth in the Interim Internet Usage Policy published in the Official Gazette of the Patent and Trademark on February 25, 1997 at 1195 OG 89.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 308-1148.

Charles Goodman
Patent Examiner
AU 3724

cg
August 10, 2000

Rinaldi I. Rada
Supervisory Patent Examiner
Group 3700

CLAIMS

1. A method for removing honeycomb and braze from a substrate, said honeycomb having a base and a ribbon direction, comprising: directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate, through at least one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle, the liquid stream striking the substrate at the base of the honeycomb, thereby removing the honeycomb and braze from the substrate, whereby the substrate may be reused.

2. A method as in Claim 1 further comprising the step of forming a laminar liquid flow out of the nozzle, wherein said nozzle has an orifice and a bore which connects said orifice to a liquid supply, with said bore having sufficient length such that a flow of liquid from said liquid supply attains a laminar flow prior to exiting said orifice.

3. A method as in Claim 1 wherein the pressure of the liquid stream is above about 20,000 psi (about 1379 bar).

4. A method of Claim 1 wherein the pressure of the liquid stream is above about 30,000 psi (about 2068 bar).

5. A method of Claim 1 wherein the pressure of the liquid stream is above 35,000 psi (about 2413 bar) to about 60,000 psi (about 4137 bar).

6. A method as in Claim 1 wherein said angle is about 35° to about 65°.

EXHIBIT

C

7. A method as in Claim 1 wherein said angle is about 40° to about 60°.

8. A method as in Claim 1 wherein said liquid stream strikes the base of the honeycomb in the ribbon direction.

"EXPRESS MAIL" MAILING LABEL NO. EL550247473US
DATE OF DEPOSIT: November 15, 2000

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 C.F.R. 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231.

Mary E. Dionne
(TYPED OR PRINTED NAME OF PERSON MAILING PAPER OR FEE)

(SIGNATURE OF PERSON MAILING PAPER OR FEE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of

M. ANTHONY STONE, et. al.

for: HONEYCOMB REMOVAL

Serial No.: 08/327,744

Filed: Oct. 24, 1994

Examiner: C. Goodman

Group Art Unit: 3724

(Our Docket No.: 3309P-65)

Box **NON-FEE AMENDMENT**
ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

AMENDMENT UNDER RULE 1.116 AND RESPONSE TO OFFICE ACTION UNDER RULE 1.113

Sir:

In response to the Office Action mailed August 15, 2000, please amend the above-referenced application as follows:

In the Claims:

Claim 1: (Twice Amended) A method for removing metal honeycomb and braze from a substrate, said honeycomb having a base and a ribbon direction, comprising: directing a pressurized liquid at an angle of less than about 90° between the liquid and the substrate, through at least one orifice of a nozzle such that the liquid forms a liquid stream upon exiting the nozzle, the liquid stream striking the substrate at the base of

EXHIBIT
D

the honeycomb, thereby removing the honeycomb and braze from the substrate, whereby the substrate may be reused.

REMARKS

After an Appeal Brief was filed October 23, 1998, prosecution of the present application was reopened and new grounds of rejection set forth in the Office Action mailed August 15, 2000. Applicant replies under 37 CFR 1.113 with Amendment under Rule 1.116 and submits herewith a Declaration under 37 CFR 1.132 traversing the new grounds of rejection.

Claims presented for prosecution in this Application are 1-8. Claims 1-8 have been rejected on new grounds over cited prior art.

Claim 1 has been amended to more particularly point out the novelty of the present invention. (Applicant notes that Exhibit B to the Appeal Brief filed Oct. 23, 1998 contains a typographical error in Claim 1. "whereby the liquid stream may be revised" should be "whereby the substrate may be reused.")

Claims 2-8 depend from and incorporate all of the limitations of independent Claim 1.

In view of the above Amendment, Applicant's Declaration submitted herewith and the remarks below, Applicant respectfully submits that claims 1-8 are now in condition for allowance. Accordingly, Applicant respectfully requests that the present Response with Amendment and Declaration be considered and entered, the rejections to the claims be withdrawn, and that the case now be passed to issue.

The 35 U.S.C. § 103 Rejection of Claims 1-8 over the combination of McComas and Shiembob, Ryan or Ackerman.

The Examiner has rejected claims 1- 8 on the grounds that it would have been obvious to combine the liquid jet removal method of McComas with the honeycomb of

either Shiembob, Ryan, or Ackerman in order to facilitate the removal of honeycomb from a substrate. 35 U.S.C. 103(a) provides:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The teaching of McComas U.S. Patent No. 5,167,721 has been discussed in previous Responses and in Applicant's Appeal Brief. In sum, McComas specifies a method for removal of coating materials, and in particular the removal of abradable, wear resistant, and thermal barrier coating materials which have been applied by either sintering powder or fibers, or by plasma spraying, utilizing liquid jet erosion.

Ackerman, U.S. Patent No. 4,218,066, discloses an apparatus for impeding the leakage of a gaseous medium between the rotating and stationary components of a gas turbine engine. Wide channel sealing techniques are discussed in combination with honeycomb facing materials.

Shiembob, U.S. Patent No. 4,433,845, discloses the manufacture of a seal for a row of turbine blades in which the seal is a honeycomb seal and a layer of insulation is positioned in the cells of the honeycomb by flame spraying. A process for accomplishing the deposition of the insulation is also described.

In Ryan, U.S. Patent No. 4,409,054, honeycomb structures, such as those used in turbine engine abradable seals, are provided with a uniform density filling of a suitable abradable material. The abradable material is prepared as a tape preform using an organic binder. The preform is forced into the honeycomb using a rubber tool.

The Examiner states that *"it would have been obvious to the ordinary artisan at the time of the instant invention to apply the liquid removal method of McComas to the abradable honeycomb seals of either Shiembob, Ryan or Ackerman in order to facilitate easy removal of the honeycomb and braze without damaging the subtrate ...."*

Applicant respectfully requests reconsideration and submits herewith a Declaration in accordance with 37 CFR 1.132, signed by inventor Clifford Mitchell traversing the rejection.

The McComas patent specifies "the removal of coating materials, and specifically to the removal of abradable, wear resistant, and thermal barrier coating materials, *which have been applied by either sintering powder or fibers, or by plasma spraying ..." (emphasis added)* (SeeTechnical Field, McComas)

There is no hint or suggestion that the removal method of McComas is applicable to *any* other material, let alone honeycomb. Applicant has amended independent claim 1 to make it clear that the honeycomb material of the present invention is a metal. As noted in Applicant's Declaration, honeycomb that is brazed onto a substrate generally has significantly higher erosion characteristics than the sprayed and sintered coatings described in McComas patent. Because of the much higher erosion characteristics for honeycomb, one skilled in the art would not use the method of McComas, - which was designed to remove plasma, rubber, fibermetal and epoxy materials from nickel, steel, titanium and aluminum substrate materials - for metal honeycomb removal.

Prior to the introduction of water jet processes to remove abradable seals, sprayed and sintered coatings were generally removed either by chemically stripping the material, - immersing it into a tank of solvent, - or by grit blasting. Metal honeycomb seal material, in contrast, with its significantly higher erosion characteristics, had to be removed using a chisel or by grinding it off. Due to the different erosion characteristics between honeycomb and sintered or sprayed barrier coating materials, which difference was well understood in the art, it was not obvious that the new method described in the McComas patent could be applied to honeycomb removal.

In fact, as indicated in the Declaration submitted herewith, after two years of experimentation with the use of ultra-high pressure water on honeycomb, the process yielded unacceptably low removal rates, (approx. .005 inches per second @ 55,000 psi).

Honeycomb was only partially removed. The wicked areas of the honeycomb and the braze could not removed with high-pressure liquid.

As indicated in Applicant's Declaration, further extensive experimentation was required to demonstrate acceptable removal rates of Hastelloy X (AMS 5536) honeycomb material and nickel-chrome braze on Hastelloy X. Applicant points out that the claims at issue in the present case are directed *specifically* to metal honeycomb and braze removal as clearly indicated in the newly amended independent claim.

If the Examiner chooses to utilize McComas in a new 35 U.S.C. § 103 rejection, Applicant respectfully requests that the Examiner provide an Affidavit or other evidence per MPEP § 2144.03, to support Examiner's contention that *"it would have been obvious to the ordinary artisan at the time of the instant invention to apply the liquid removal method of McComas to the abradable honeycomb seals of either Shiembob, Ryan or Ackerman in order to facilitate easy removal of the honeycomb and braze without damaging the substrate ..."*

Applicant earnestly believes that independent claim 1 clearly defines over McComas in combination with either Shiembob, Ryan, or Ackerman. With particular respect to dependent claims 2-8 Applicant asserts that claims 2-8 themselves contain allowable subject matter as well as being allowable at least for the reasons that independent claim 1 is allowable, as discussed above. Therefore, Applicant respectfully requests withdrawal of the 35 U.S.C. § 103 rejection of claims 1-8.

Finally, with respect to the Examiner's statement that McComas teaches a method of removal of coatings, *"including the inherent step of having the liquid stream striking the substrate at the base of the coating, since, inter alia, this striking position is the obvious position that facilitates simultaneous removal of the coating and bond coating from the substrate, ..."* Applicant respectfully urges that McComas does not teach simultaneous removal of the top coating and bond coating by having the liquid strike the substrate at the base of the coating. To the contrary, McComas Independent Claim 1 specifically teaches sequential removal of the top coat and bond coat. See McComas Claim 1 step d. *"causing the liquid to strike the top coat, wherein the liquid striking the top coat causes top*

coat erosion until the bond coat is exposed.". With reference to the Appeal Brief filed Oct. 23, 1998, Applicant reiterates that no combination of references teach or suggest positioning the pressurized liquid to strike the substrate at the base of the honeycomb.

CONCLUSION

In view of the Amendment to Independent Claim 1, the Declaration submitted herewith and the remarks above, it is respectfully submitted that claims 1-8 are allowable, and an early action to that effect is earnestly solicited.

The Examiner is invited to contact the undersigned at the number below to expedite resolution of any issues that the Examiner may consider to remain unresolved. In particular, should a Notice of Allowance not be forthcoming, the Examiner is requested to phone the undersigned for a telephonic interview while the outstanding issues are fresh in the mind of the Examiner.

In the event that the Examiner is not persuaded by the arguments and Amendment set forth herein, Applicant respectfully request that this response with Amendment and Declaration be admitted for purposes of placing the application in better condition for appeal to the Board of Appeals.

It is believed that no additional fees or deficiencies in fees are owed. However, authorization is hereby given to charge our Deposit Account No. 13-0235 in the event any additional fees are owed.

Respectfully submitted,

By _____
Susan C. Oygard
Registration No. 42,969
Attorney for Applicant

McCORMICK, PAULDING & HUBER LLP
CityPlace II, 185 Asylum Street
Hartford, CT 06103-4102
Tel.: (860) 549-5290
Fax: (860) 527-0464

"EXPRESS MAIL" MAILING LABEL NO. EL550247473US
DATE OF DEPOSIT: November 15, 2000

I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 C.F.R. 1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231

Mary E. Dionne
(TYPED NAME OF PERSON MAILING PAPER OR FEE)

(SIGNATURE OF PERSON MAILING PAPER OR FEE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In the Application of	)	
	)	Examiner: C. Goodman
M. ANTHONY STONE, et. al	)	
	)	Group Art Unit: 3724
for: HONEYCOMB REMOVAL	)	
	)	
Serial No.: 08/327,744	)	
	)	(Our Docket No.: 3309P-65)
Filed: Oct. 24, 1994	)	

DECLARATION OF CLIFFORD V. MITCHELL

37 CFR 1.132

I, Clifford V. Mitchell, one of the named inventors on the above cited patent application, hereby state the following:

1. I am employed at Pratt & Whitney Advanced Systems Technologies, Inc., (AST) Huntsville, Alabama. I have been employed by AST (formerly Waterjet Systems, Inc. and USBI) for approx. 12 years. My present position is Manager, Huntsville Service Center & Process Engineering. I have 12 years experience in ultra-high pressure water application engineering and 20 years experience in Gas Turbine Engine refurbishment.

2. Honeycomb is a formed metal structure braze bonded to a metal substrate. Plasma/sintered coatings are sprayed powders layered to a metal substrate. The honeycomb material and braze described in the present application has a much higher erosion characteristic than the plasma sprayed and sintered coatings described in U.S.

EXHIBIT

E

patent no. 5,167,721 to McComas. Therefore, the methods typically employed to remove sprayed and sintered coatings such as plasma, rubber, fibermetal and epoxy materials from base materials such as nickel, steel, titanium, and aluminum are not generally applicable to honeycomb removal.

3. Prior to the introduction of high pressure liquid processes, sprayed and sintered coatings were typically removed either by a chemical strip or grit blasting; honeycomb was typically removed by grinding and/or a chisel.

4. Two years of initial work on the present invention demonstrated only a limited capability of ultra-high pressure water to remove honeycomb. Removal rates were unacceptably low (.005 ips at 55,000 psi) and honeycomb in wicked areas and the braze were not removed at all.

5. Only after extensive further experimentation with the present method were increased removal rates for honeycomb and braze demonstrated.

6. Engine overhaul and repair customers have expressed a long felt need for a honeycomb removal process that does not damage the substrate. Present machining techniques to remove honeycomb result in an unacceptably high scrap rate.

I declare that all statements herein made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements and the like are punishable by fine or imprisonment, or both (18 USC 1001) and may jeopardize the validity of the application or any patent issuing thereon.

11/1/00

Clifford V. Mitchell

US005167721A

United States Patent [19]

McComas et al.

[11] Patent Number: 5,167,721

[45] Date of Patent: Dec. 1, 1992

[54] **LIQUID JET REMOVAL OF PLASMA SPRAYED AND SINTERED**

[75] Inventors: Charles C. McComas, Palm City; John W. Appleby, Jr., Palm Beach Gardens; Gerard A. Sileo, Royal Palm Beach, all of Fla.; Herbert R. Barringer, Midwest City; Michael J. Patry, Oklahoma City, both of Okla.

[73] Assignee: United Technologies Corporation, Hartford, Conn.

[21] Appl. No.: 784,625

[22] Filed: Dec. 5, 1991

Related U.S. Application Data

[63] Continuation of Ser. No. 441,666, Nov. 27, 1989, abandoned.

[51] Int. Cl.[5] B08B 3/02

[52] U.S. Cl. 134/32; 134/34; 134/38

[58] Field of Search 134/2, 22.12, 22.18, 134/24, 32, 34, 38, 40

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,653,116	9/1953	Whitcomb et al.	134/10
3,413,136	11/1968	Emanuelson et al.	117/8
3,460,296	8/1969	Dittmar et al.	51/320
4,055,705	10/1977	Stecura et al.	428/633
4,285,108	8/1981	Arrigoni	29/156.8
4,339,282	7/1982	Lada et al.	134/3
4,425,185	1/1984	Fishter et al.	156/656
4,508,577	4/1985	Conn et al.	134/22.12
4,552,594	11/1985	Van Voskuilen et al.	134/34
4,590,026	5/1986	Goto	264/221
4,607,792	8/1986	Young, III	239/101
4,726,104	2/1988	Foster et al.	29/156.8
4,859,249	8/1989	Valentini	134/24

FOREIGN PATENT DOCUMENTS

0145988	6/1985	European Pat. Off. .
0400758	12/1990	European Pat. Off. .
2630667	11/1989	France .
1362111	7/1974	United Kingdom .
2042399	1/1979	United Kingdom .
2217234	10/1989	United Kingdom .

OTHER PUBLICATIONS

New Zealand Patent No. 176547 dated Feb. 1977 claims 1-10 and FIGS. 1 and 2 only.

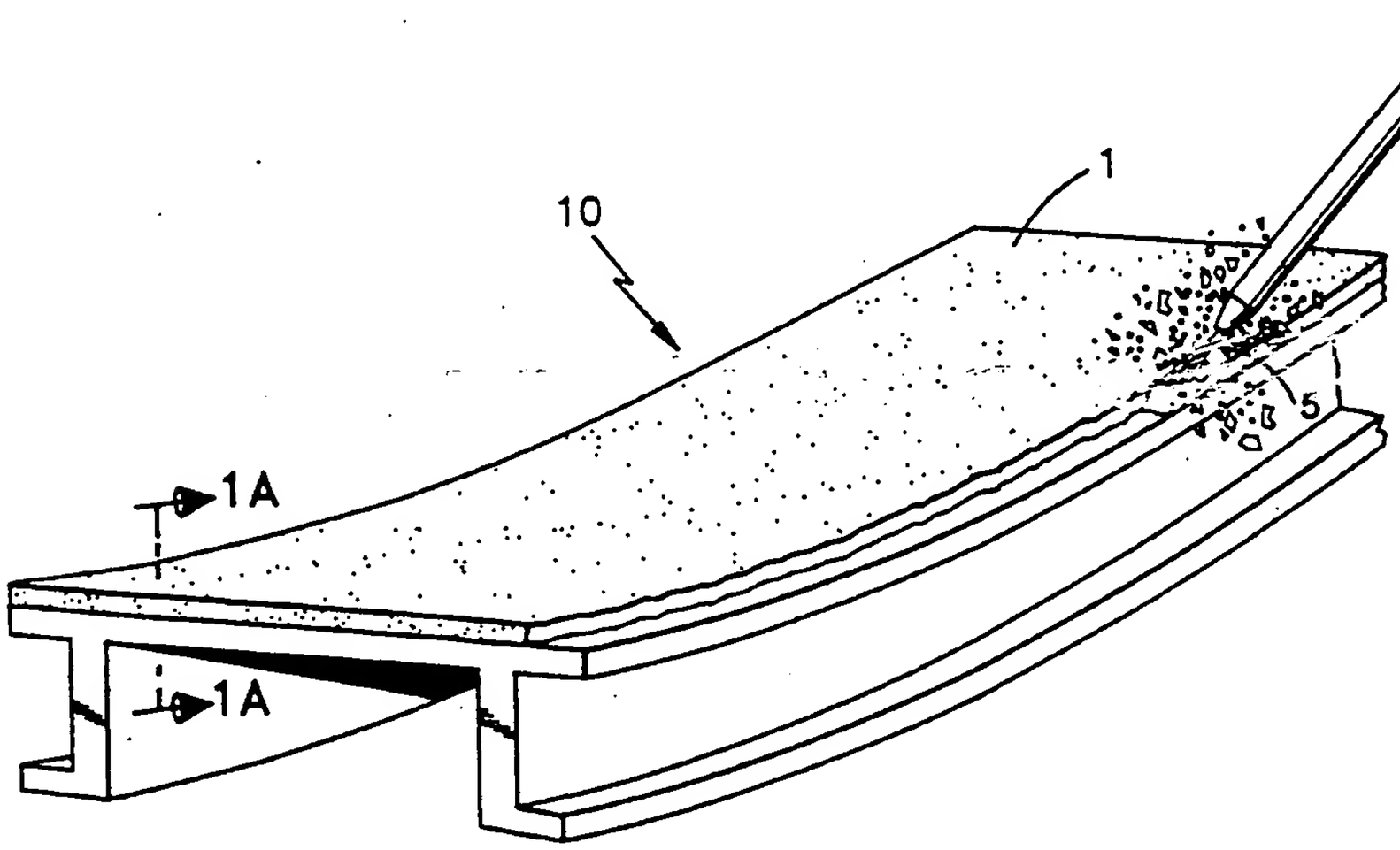
New Zealand Patent No. 173992 dated Mar. 1976 claims 1-20 and FIGS. 1-3 only.

Primary Examiner—Theodore Morris
Assistant Examiner—Saeed Chaudhry
Attorney, Agent, or Firm—Pamela J. Curbelo

[57] **ABSTRACT**

Gas turbine engine coatings must often be removed during engine maintenance and repair. The techniques utilized to accomplish this task, machining, chemical stripping, machining followed by chemical stripping, or grit blasting, frequently result in component damage or destruction. Liquid jet erosion can be utilized to remove seals, coatings, or portions thereof without damaging the engine hardware.

13 Claims, 2 Drawing Sheets



EXHIBIT

G

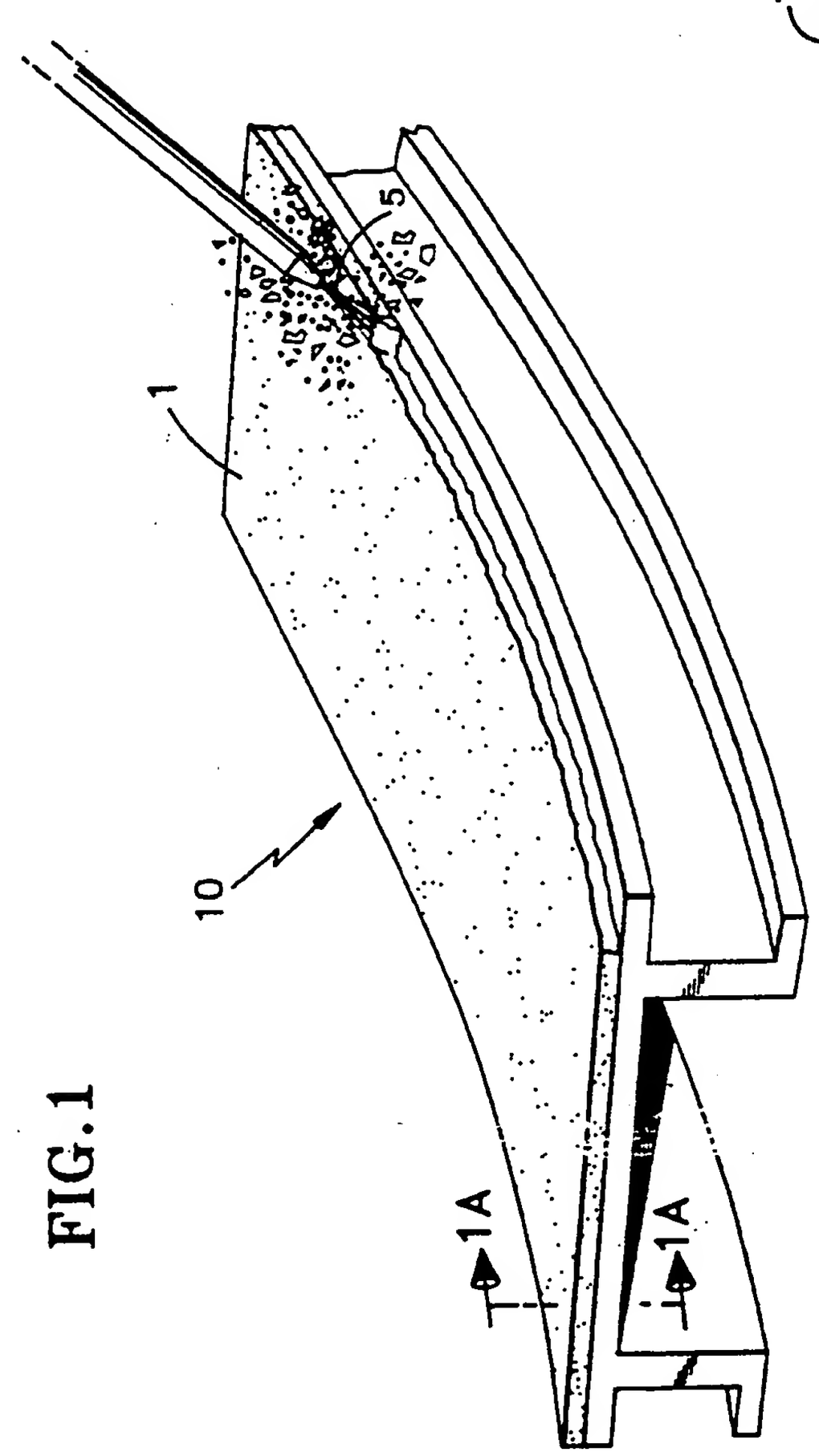


FIG. 1

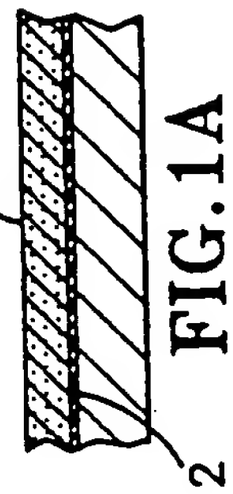
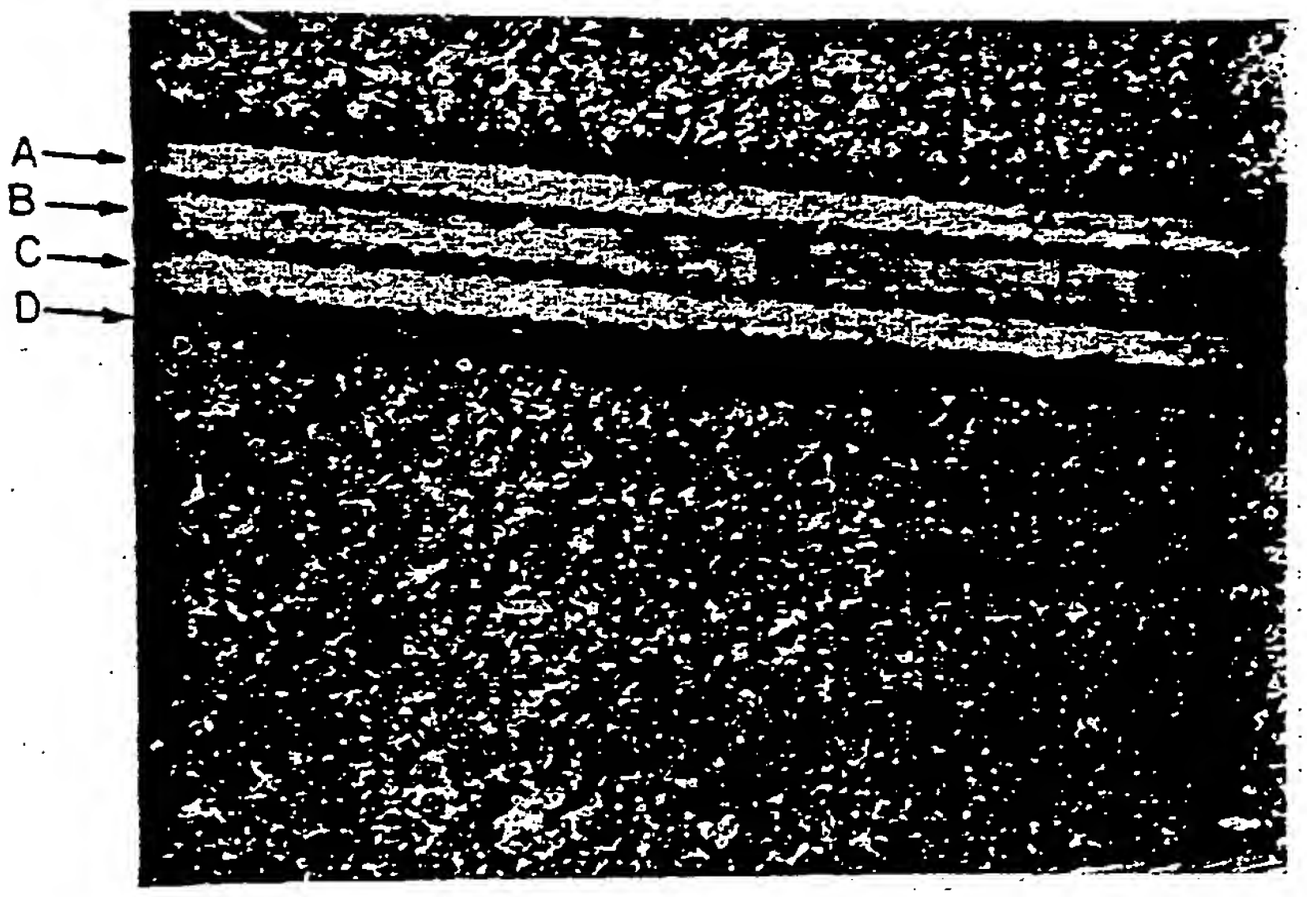


FIG. 1A

FIG. 2



LIQUID JET REMOVAL OF PLASMA SPRAYED AND SINTERED

The Government has rights in this invention pursuant to a contract awarded by the Department of the Air Force.

This application is a continuation of Ser. No. 07/441,666 filed Nov. 27, 1989 now abandoned.

TECHNICAL FIELD

This invention relates to the removal of coating materials, and specifically to the removal of abradable, wear resistant, and thermal barrier coating materials which have been applied by either sintering powder or fibers, or by plasma spraying, utilizing liquid jet erosion.

BACKGROUND ART

Various types coatings and sintered materials are used in numerous applications, such as in gas turbine engines to increase efficiency and/or protect components from heat and wear. Types of materials include thermal barrier coatings, abrasive coatings, abradable seals, and hard facing; hereafter referred to as coatings.

Since excessive blade/case clearances and disc/vane clearances within turbine engines allow the escape of gases which decreases engine efficiency, an abradable seal can be applied to minimize the clearances between the rotating and the stationary components. Thermal barrier coatings can be utilized to provide protection against high temperatures, while abrasive coatings can be used to prevent detrimental rub interactions and hard facing can be used to reduce wear.

Some coatings are applied by plasma or flame spraying; introducing particles (usually powders) into a hot gas stream or flame (respectively) which causes the particles to splat onto the substrate surface where they adhere and build up as a coating. Application of particles (i.e. AB-1) or short wires (i.e. Feltmetal TM) onto a substrate; by pre-sintering or partial sintering and then brazing, can be used to produce abradable coatings comprised of bonded particles, wires, or powders and void spaces; while bond coats can be produced by plasma spraying or vapor deposition. Bond coats are usually used in plasma spray and vapor deposition applications; a bond coat being a layer of metallic composition applied to the substrate before the coating is applied. U.S. Pat. Nos. 3,542,530, 3,676,085, 3,754,903, 3,879,831, 3,928,026, and 4,704,332, (incorporated herein by reference) describe various coatings, while U.S. Pat. Nos. 3,413,136, 4,055,705, and 4,321,311 (incorporated herein by reference) describe application techniques.

A common characteristic of these types of coatings is that the coating strength (cohesive strength) is relatively low; plasma sprayed or partially sintered particles are not well bonded to each other and there is usually porosity present. The strength of the coating is less than that of the substrate.

During engine maintenance, these coatings must frequently be removed; a process difficult to reliably preform and which frequently results in substrate damage. Various techniques have been employed for the removal of coatings: machining, chemical stripping, machining followed by chemical stripping (see for example U.S. Pat. Nos. 4,339,282, and 4,425,185; incorporated herein by reference), and grit blasting. For example, machining followed by chemical stripping requires that the component be held stationary while a machining tool removes the majority of the coating. A chemical solution, usually either a very strong acid or base, is then applied to the coating surface to disintegrate the remaining coating material. This technique requires extreme precision; without proper hardware alignment during machining damage to the substrate material occurs, while the chemical solution used tends to attack the substrate material. This process is also time consuming and labor intensive. Additionally, the chemical step, can produce hazardous waste. The individual processes of chemical stripping and machining also have the above described problems.

Another commonly used method, abrasive or grit blasting, also often results in damaged or destroyed components. This process consists of projecting abrasive particles in a compressed air stream against the coating. Since this technique requires immediate termination upon substrate exposure to prevent damage, it requires skilled operators.

Liquid jets above 10,000 psi, to the best of our knowledge, have not been utilized in the removal of coatings. Relatively low pressure liquid jets, 2,000 to 3,000 psi, have been applied in areas such as: cleaning applications, nuclear contamination removal, concrete scarifying, and barnacle and hull fouling removal, but not in an inorganic coating removal process.

Accordingly, an objective of this invention is to provide a convenient, cost effective, environmentally safe technique of removing coatings.

DISCLOSURE OF INVENTION

The present invention involves the removal of coatings utilizing a liquid jet erosion process. The liquid jet, while striking the coating at an angle, traverses the region, removing the coating. Depending on the liquid pressure, the liquid stream erodes the abradable seal/-thermal barrier with virtually no damage to the bond coat (if present), or can remove both the abradable seal/thermal barrier and bond coat simultaneously without substrate damage.

The invention process can be used to remove plasma sprayed and sintered coatings whose cohesive strength is significantly less than that of the substrate.

The foregoing and other features and advantages of the present invention will become more apparent from the following description and accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a basic embodiment of this invention.

FIG. 1A is a cross-section of FIG. 1 which reveals the various layers of the coating.

FIG. 2 shows the results of utilizing a liquid jet removal process at varying pressures.

BEST MODE FOR CARRYING OUT THE INVENTION

The removal of coatings using current techniques is a difficult, inexact process. It requires skilled technicians, a substantial amount of time, expensive equipment, and frequently, the component is destroyed.

The removal of the coating, bond coat, or both without damage to the substrate material can be achieved with a liquid jet erosion technique; making it a viable alternative to the prior art.

As previously mentioned, this invention uses a liquid jet erosion process to remove coatings. Critical parameters (see FIG. 1) include the nozzle distance from the

coating, and the liquid pressure. Depending on equipment and pressure constraints, the nozzle can be placed up to approximately 6 or even 12 inches from the coating surface, however, lesser distances are preferred, with ¼ to ¾ inch especially preferred.

The angle between the liquid jet and similarly the liquid contact, and the coating is a matter of preference. An angle of between 20° to 90° can be used, with an angle of between 30° and 90° preferred, and an angle of about 45° especially preferred (see FIG. 1). The angle, not a critical parameter, causes the liquid to remove the coating fragments from the region where the jet impacts the coating. The direction of rotation effects the fragment location post-removal. It is preferred to rotate the component such that it causes the liquid stream to move toward the smallest angle formed between the liquid stream and the component. Although this is merely a matter of preference, this rotation directions helps to remove the fragments from the interaction zone thereby ensuring that they to do not interfere with the process.

FIG. 1 is one embodiment of the invention. The liquid stream (5) contacts the coating (1) at the preferred angle, approximately 45°. Additionally, the component (10) rotates such that the liquid stream (5) moves toward the smallest angle between the liquid stream (5) and the component (10) (see arrows (1A)).

The liquid stream can consist of any liquid having a viscosity between 0.25 centipoise and 5.00 centipoise at 25° C. and 1 atm and which will not damage the bond coat or substrate material, including water based liquids. Higher viscosity liquids tend to present flow problems with respect to spraying the liquid at high pressures, while lower viscosity liquids can be difficult to pressurize, possibly increasing equipment costs. Water, viscosity approximately 0.95 centipoise at 25° C. and 1 atm, is preferred for reasons of cost and waste disposal. Additives, such as wetting agents, or various chemicals which will degrade the coating without damaging the component, may also be useful.

A water jet pressure sufficient to remove the top coat and/or the top coat and the bond coat is required. Since pressures greater than about 60,000 psi will damage most gas turbine substrate materials, lower pressures must be used. The optimum liquid pressure ranges from about 20,000 to about 60,000 psi, with about 25,000 to about 40,000 psi preferred. The factors which determine the exact pressure required include the type of top coat and if the coating is to be removed down to the bond coat or to the substrate. (see FIG. 1A; top coat (1) and bond coat (2)). Exact pressure limits are also related to nozzle geometry and spacing, and to the specific substrate involved. In practice, the skilled artisan can readily determine the pressure which causes substrate damage and/or the pressure which causes bond coat removal, and reduce this pressure to arrive at a suitable process pressure.

FIG. 2 shows the effects of varying pressures when using this invention. As the pressures decreased, from run (A) to (D), the amount of seal removed also decreases, to the point where the abradable seal/thermal barrier is removed with virtually no damage to the bond coat, (D).

This invention will be made clearer with reference to the following illustrative examples.

EXAMPLE 1

The following procedure is used to remove a plasma sprayed hard face coating, top coat and bond coat, (consisting of 20 v/o of an 80 nickel, 20 chromium alloy, balance chromium carbide) from a substrate material.

1. The coated substrate material is arranged such that relative motion can be produced between it and the water jet nozzle.
2. The water jet nozzle is placed so that the exit end of the nozzle is about ¼ inch from the coating and the water stream contacts the coating at an angle of 45° (refer to FIG. 1).
3. The water pressure is 40,000 psi.
4. Relative motion is created between the water stream and the coating such that as the coating is removed the component advances to the next region to be removed.
5. The removal time is dependant upon the surface area of the coating. The time will range from 5 minutes to 10 minutes for typical gas turbine engine components.

EXAMPLE 2

A sintered abradable coating (consisting of approximately 65 v/o nickel, 35 v/o chrome, balance aluminum) can be removed by following the specifications set forth in Example 1, while substituting a pressure of 35,000 psi for the 40,000 psi in step 4.

This process can be used for any coating which has strength less than that of the substrate, by adjusting the pressure such that it removes the top coat without bond coat damage, or the bond coat without substrate damage, allowing reuse of the bond coat and substrate or the substrate respectively.

Although this invention has been shown and described with respect to detailed embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the spirit and scope of the claimed invention.

We claim:

1. A method for removing a top coat from a bond coating adhered to a substrate, utilizing a liquid jet, said liquid jet having means for directing the liquid jet, means for creating sufficient pressure to remove the coating, means to provide the relative motion between the coating and the liquid jet, and means for supplying the liquid, which comprises:
   a. creating sufficient pressure to remove the coating;
   b. providing relative motion between the coating and the liquid jet;
   c. supplying the liquid;
   d. causing the liquid to strike the top coat, wherein the liquid striking the top coat causes top coat erosion until the bond coat is exposed;

whereby the bond coat and the substrate suffer essentially no damage and can be reused.

2. A method as in claim 1 wherein the top coat is selected from the group of plasma sprayed, flame sprayed, and sintered coatings.

3. A method as in claim 1 wherein the top coat is an abradable.

4. A method as in claim 1 wherein the top coat is a thermal barrier.

5. A method as in claim 1 wherein the top coat is an abrasive.

6. A method as in claim 1 wherein the coating is a hard facing.

7. A method as in claim 1 wherein the liquid pressure is from about 20,000 psi to about 60,000 psi.

8. A method as in claim 1 using a nozzle as the means for directing the liquid flow.

9. A method as in claim 1 wherein the liquid is selected from the group of liquids consisting of all liquid which does not degrade the bond coat, and has a viscosity between about 0.25 centipoise and about 5.00 centipoise at 25° C. and 1 atm.

10. A method as in claim 1 wherein the liquid is selected from the group consisting of water based liquids.

11. A method as in claim 1 wherein the liquid is essentially water.

12. A method as in claim 1 wherein the angle between the liquid stream and the top coat is between 20° and 70°; whereby the angle causes the liquid stream to clean away the coating fragments.

13. A method as in claim 1 further comprising the step of removing the bond coating, wherein the substrate material suffers essentially no damage.

* * * * *

United States Patent [19]

Shiembob

[11] **4,433,845**

[45] **Feb. 28, 1984**

[54] **INSULATED HONEYCOMB SEAL**

[75] Inventor: **Lawrence T. Shiembob, Rocky Hill, Conn.**

[73] Assignee: **United Technologies Corporation, Hartford, Conn.**

[21] Appl. No.: **306,838**

[22] Filed: **Sep. 29, 1981**

[51] Int. Cl.³ **F16J 15/40**

[52] U.S. Cl. 277/1; 277/53; 277/227; 415/174; 427/423

[58] **Field of Search** 277/53, 1; 415/174, 415/177; 427/423, 34

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,042,365	7/1962	Curtis et al.	277/53
3,720,419	3/1973	Adelizzi	277/53
3,834,001	9/1974	Carroll et al.	277/1
4,336,276	6/1982	Bill et al.	415/174

Primary Examiner—Robert I. Smith

Attorney, Agent, or Firm—Charles A. Warren

[57] **ABSTRACT**

The application discloses the manufacture of a seal for a row of turbine blades in which the seal is a honeycomb seal and a layer of insulation is positioned in the cells of the honeycomb by flame spraying. A process for accomplishing the deposition of the insulation is also described.

6 Claims, 3 Drawing Figures

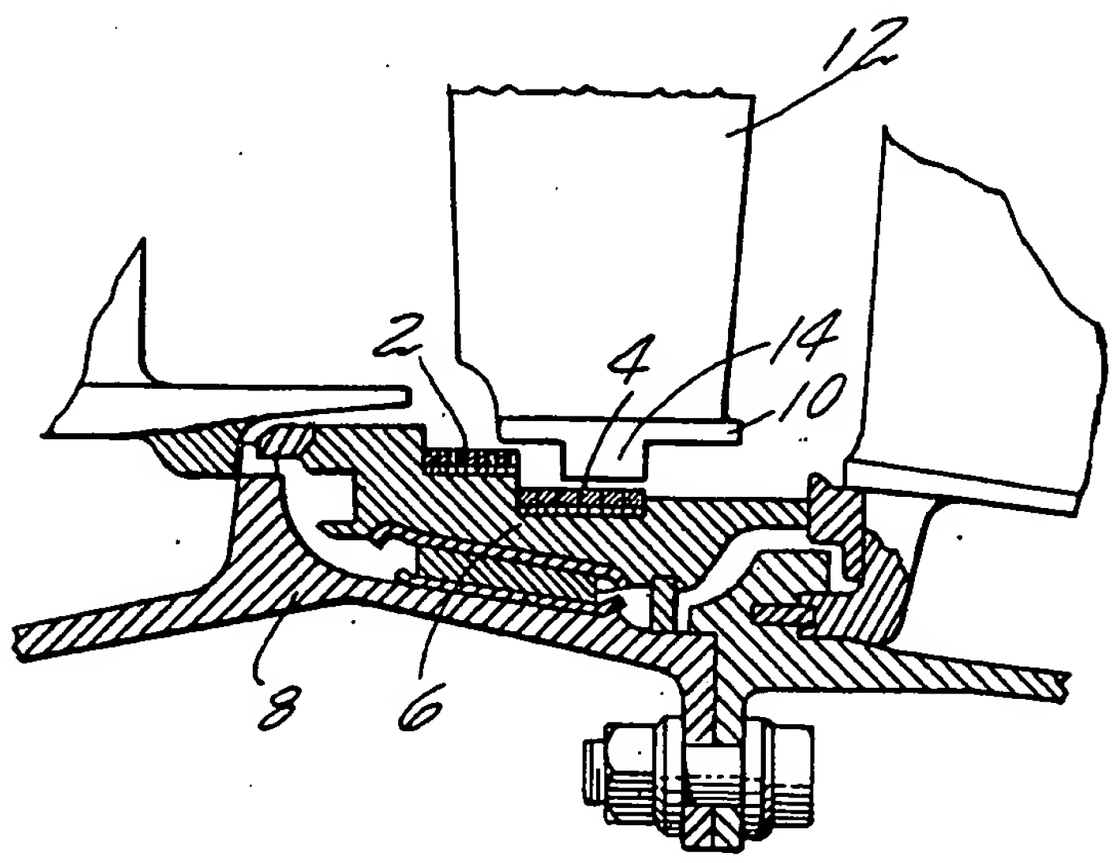


Fig. 1

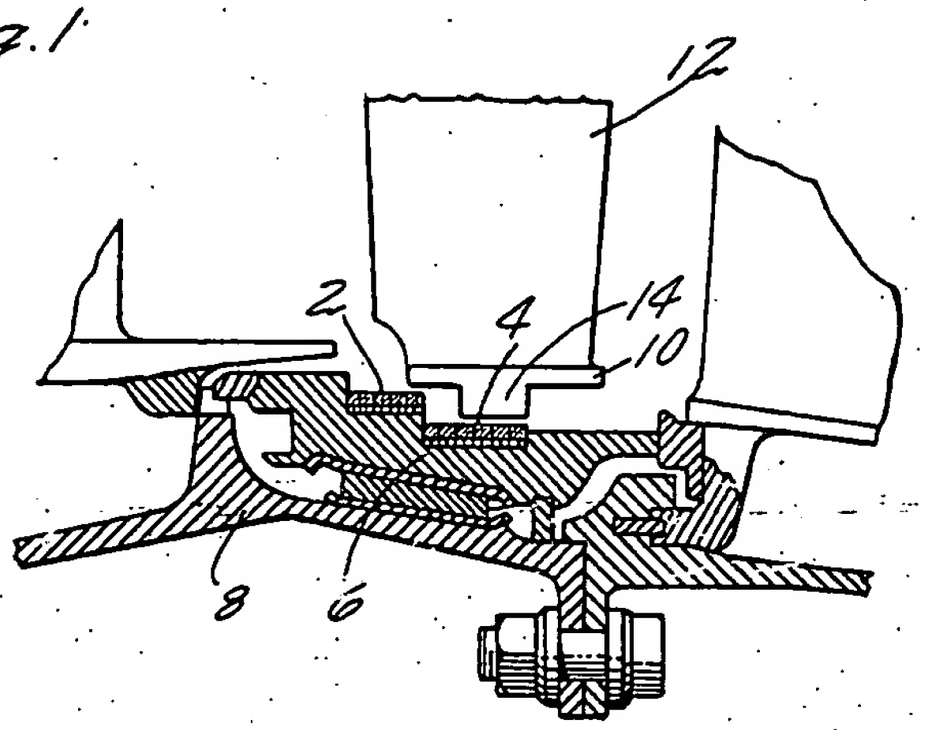


Fig. 3

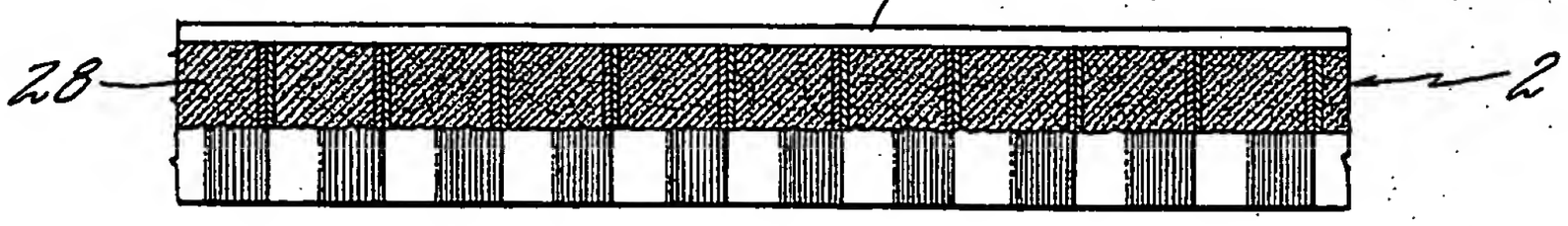
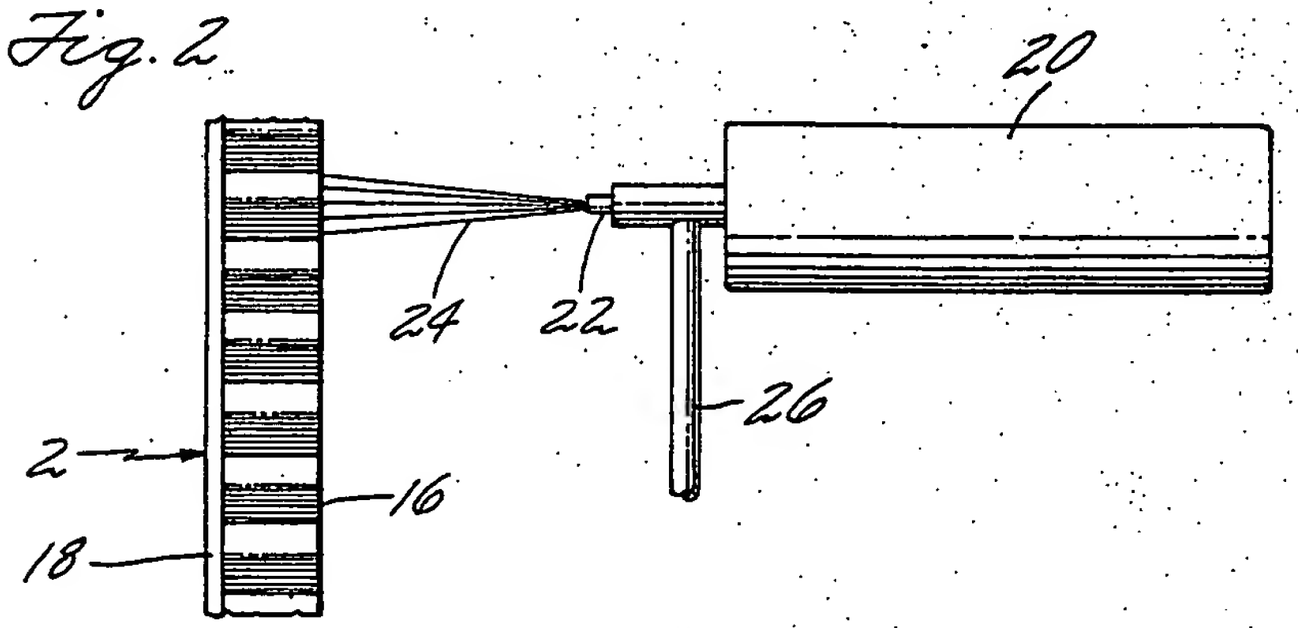


Fig. 2



INSULATED HONEYCOMB SEAL

DESCRIPTION

1. Technical Field

This invention relates to honeycomb type of seals for gas turbine engines in which the seal that surrounds a row of blades in the engine is at least partially filled with an insulating material to reduce the thermal gradients in the turbine case and thus minimize contact between the blades and the seal.

2. Background Art

To reduce the gas path seal clearances during engine transients attempts have been made to insulate the seals and their supports to reduce the thermal response of the parts. Where the seal is a honeycombed material the honeycomb has been filled with a paste form of insulation which is then brazed or sintered to set and bond the material. This procedure is difficult to monitor to assure a uniform filling of the honeycomb with the result that there is uneven insulation throughout the honeycomb. When it is desirably only to partially fill the honeycomb in certain installations, a uniform filling to the extent desired is even more difficult.

DISCLOSURE OF INVENTION

One feature of the invention is the application of the coating of the insulating material as a powder by flame spraying this powder to the desired depth of thickness in the cells of the seal. Another feature is the use of a NiCrAl/bentonite powder as the insulating material. Another feature is the use of this powder in flame spraying applications which provide the desired bond and insulating properties as well as the desired hardness of the coating.

According to the invention a suitable insulating poweder is deposited to the desired depth or thickness in the honeycomb seal by flame spraying the powder into the cell structure of the honeycomb. The desired insulating powder is a NiCrAl/bentonite powder in which the particles consist of a bentonite core coated with a mixture of NiCrAl. The principal feature of the invention is the application of an insulating powder to the cells of a honeycomb by a flame spraying procedure by which to assure a uniform application of the insulating coating to the desired depth in the honeycomb and to produce an insulating structure that has the desired characteristics without further treatment beyond the flame spraying.

The foregoing and other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of the preferred embodiment thereof as shown in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary sectional view through a turbine showing the location of the honeycomb seal.

FIG. 2 is an enlarged sectional view showing the coating applied to the seal.

FIG. 3 is an enlarged sectional view of the seal.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring to FIG. 1 the honeycomb seals 2 and 4 are shown as supported by a seal ring 6 positioned within the turbine casing 8. The seal 2 has a smaller diameter than the seal 4 and engages the shrouds 10 of the turbine

blade 12 adjacent to the leading edges of these shrouds. The seal 4 has a larger diameter and surrounds and is closely adjacent to a central rib 14 on the shrouds. Desirably the seals have a minimum of clearance with the shrouds to reduce the leakage of gas past the seals and the honeycomb material is selected as a seal since it will wear away readily in the event of contact with the blade shrouds during engine transients without any detrimental effect on the turbine.

It is desirable to reduce the heat transfer from the gas going through the turbine to the seals thereby reducing the rate of change in diameter of the seals during engine transients. As above stated this has been done by manually packing an insulating material in paste form into the honeycomb seals. Such a procedure is time consuming and does not result in a uniform distribution of the paste in the openings of the seal particularly, if the seal openings are to be only partially filled. To provide a better and more dependable insulation it has been found that suitable insulating powders may be flame sprayed into the seal and will produce the desired uniform insulating effect with the desired depth of insulation in the honeycomb spaces or cells. Further the flame spraying produces a better adherence of the insulating material with more uniform insulating properties. The material is also cured to the desired hardness by the flame spraying thereby avoiding any further heat treatment of the seal with the insulation therein.

Referring now to FIG. 2 the seal 2 being honeycomb has openings or spaces 16 therein extending radially and the outer ends of these spaces or cells are closed by the surrounding seal ring 18. To accomplish the desired insulation of this seal a suitable insulating powder having desired insulating characteristics is flame sprayed into the spaces or cells to the desired length. In the particular seal shown the cell dimension is one-sixteenth inch and the height of the honeycomb is 0.100 inch. The powder is flame sprayed into the cells to provide insulation 28 to a depth of 0.050 ± 0.020 inch within the cell. It will be understood that these dimensions are given by way of example and the cell size or depth of insulation are not critical to the invention.

The preferred powder consists of particles of bentonite which is normally 70% SiO_2 and 20% Al_2O_3 by weight and these particles are coated with a mixture of NiCrAl to produce a composition in the powder of chromium 1.5 to 6.5%, aluminum 1.0 to 6.0%, bentonite 18 to 24%, nickel remainder. It will be understood that any insulating powder capable of being applied by flame spraying may be used instead of this particular powder although it is known that this particular powder produces a very satisfactory insulating coating. The seals are preferably cleaned before flame spraying to assure a cool bond with the insulating material and the powder is then sprayed in with conventional spray equipment capable of producing the desired coating density.

The insulating powder may be sprayed on, for example, by a flame sprayer 20 having a nozzle 22 discharging a flame 24 against the seal. The powder is applied by a tube 26 delivered through the nozzle to enter the flame and be deposited on the seal. The nozzle is moved axially relative to the seal and parallel to the surface thereof while the part is rotating for depositing the material. The nozzle is also desirably reciprocated axially past the seal during the circumferential movement to assure a uniform deposit in all of the cells of the seal. The normal flame spray deposition covers a relatively

small area and would not normally be wide enough to fill the cells across the entire width of the seal without this axial movement. The insulation 28 is shown as applied only from the bottom of the cell up to the desired depth. It has been found that by flame spraying in the manner described substantially none of the insulating powder adheres to the side walls of the seal between the insulation and the open end of the seal.

One critical time in turbine operation is during deceleration when the cooler gas passing over the seals and the support structure causes these structures to shrink more rapidly than the rotor with the possibility of seal and shroud contact. This particular arrangement of insulation reduces the rate of shrinking of the seal to avoid this seal and shroud contact. Since engine clearances are set for this condition the use of this insulation enables a reduction in the engine design clearances at this point and the result is a higher-performance engine because of reduced leakage past the seal.

Although the invention has been shown and described with respect to a preferred embodiment thereof, it should be understood by those skilled in the art that other various changes and omissions in the form and detail thereof may be made therein without departing from the spirit and the scope of the invention.

I claim:

1. In the manufacture of a seal for a row of turbine blades the steps of:

providing a honeycomb seal with the cells therein substantially radial;

closing the outer ends of the cells by a surrounding ring; and

flame spraying an insulating material into the cells to fill at least partially the cells radially inward from the outer ends, the insulating material being clay particles with an alloy coating and

curing this material to the desired hardness by the heat of the flame spraying.

2. The process of claim 1 including the step of using as the insulating material to be flame sprayed a powder in which the particles are NiCrAl/bentonite.

3. The process of claim 1 in which the particles are in the form of a core or bentonite with a NiCrAl coating thereon.

4. A turbine seal for a row of turbine blades including:

a honeycomb seal ring in which the cells of the honeycomb extend radially;

a surrounding ring closing the outer ends of the cells; and

an insulating material positioned in said cells by flame spraying an insulating powder into said cells in which the insulating material is a clay base combined with a metallic alloy, that is heat cured to the desired hardness in the flame spraying operation.

5. A turbine seal as in claim 4 in which the material that is flame sprayed is in the form of particles having a bentonite core and NiCrAl coating.

6. A turbine seal as in claim 4 in which the insulating material is NiCrAl/bentonite.

* * * * *

United States Patent [19]

Ryan

[11] **4,409,054**

[45] **Oct. 11, 1983**

[54] **METHOD FOR APPLYING ABRADABLE MATERIAL TO A HONEYCOMB STRUCTURE AND THE PRODUCT THEREOF**

[75] Inventor: **Edward J. Ryan, Wallingford, Conn.**

[73] Assignee: **United Technologies Corporation, Hartford, Conn.**

[21] Appl. No.: **225,074**

[22] Filed: **Jan. 14, 1981**

[51] Int. Cl.³ B29C 19/00; B32B 31/00; B32B 3/12; B23K 35/24

[52] U.S. Cl. 156/293; 156/298; 228/243; 228/256; 415/174; 29/DIG. 4; 428/117

[58] Field of Search ..... 228/182, 248, 243, 245, 228/254, 255; 415/174; 277/81 R, 95; 29/432, DIG. 31, DIG. 4; 156/154, 293, 298, 303.1, 82, 89; 165/69, 1; 428/117, 446, 430, 553, 443, 555; 419/1, 4, 20

[56] **References Cited**

U.S. PATENT DOCUMENTS

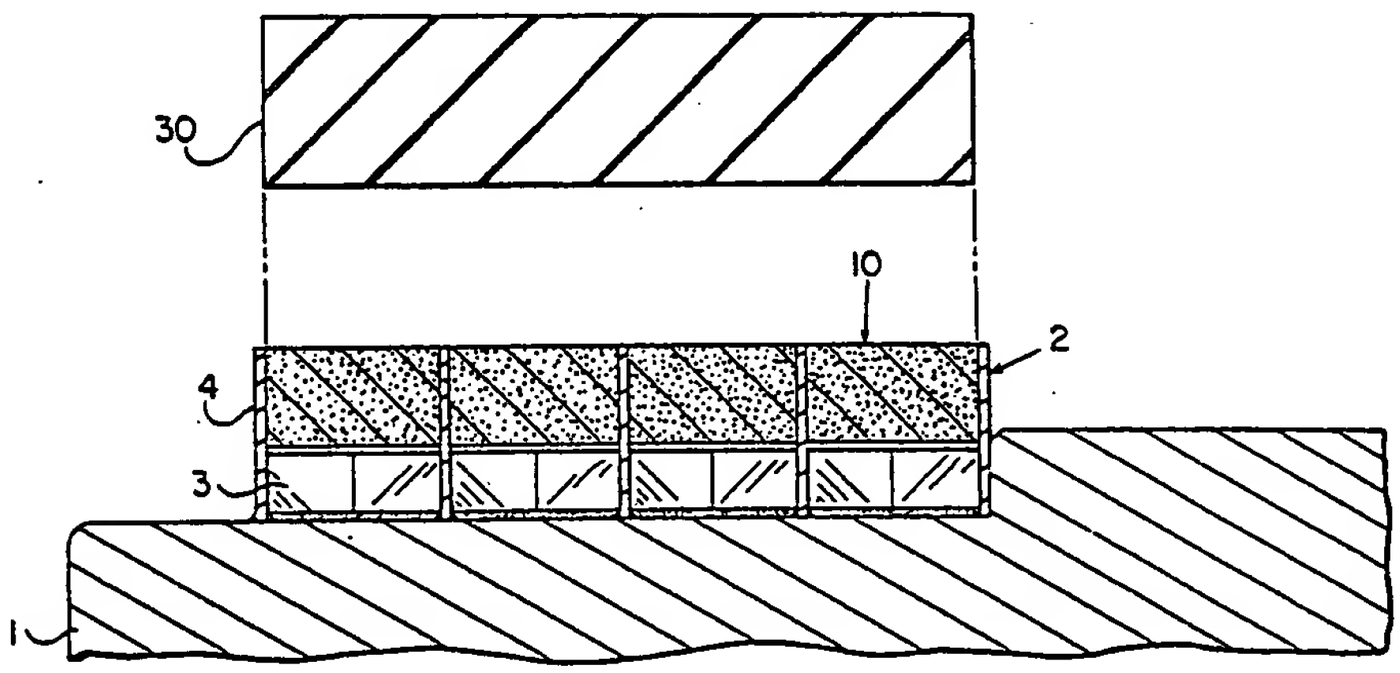
2,181,466	11/1939	Shackett	428/117
3,053,694	9/1962	Daunt et al.	415/174
3,139,369	6/1964	Sullivan et al.	428/117
3,180,774	4/1965	Koch	156/298
3,293,072	12/1966	Doolittle et al.	428/430
3,630,813	12/1971	Allen	428/117
3,926,156	12/1975	McCormick	165/69
3,956,050	5/1976	Dow et al.	428/117
4,045,268	8/1977	Geschwender	428/117
4,349,313	9/1982	Munroe et al.	415/174

Primary Examiner—Edward C. Kimlin
Assistant Examiner—Louis Falasco
Attorney, Agent, or Firm—Charles E. Sohl

[57] **ABSTRACT**

Honeycomb structures, such as those used in turbine engine abradable seals, are provided with a uniform density filling of a suitable abradable material. The abradable material is prepared as a tape preform using an organic binder. The preform is forced into the honeycomb using a rubber tool.

1 Claim, 4 Drawing Figures



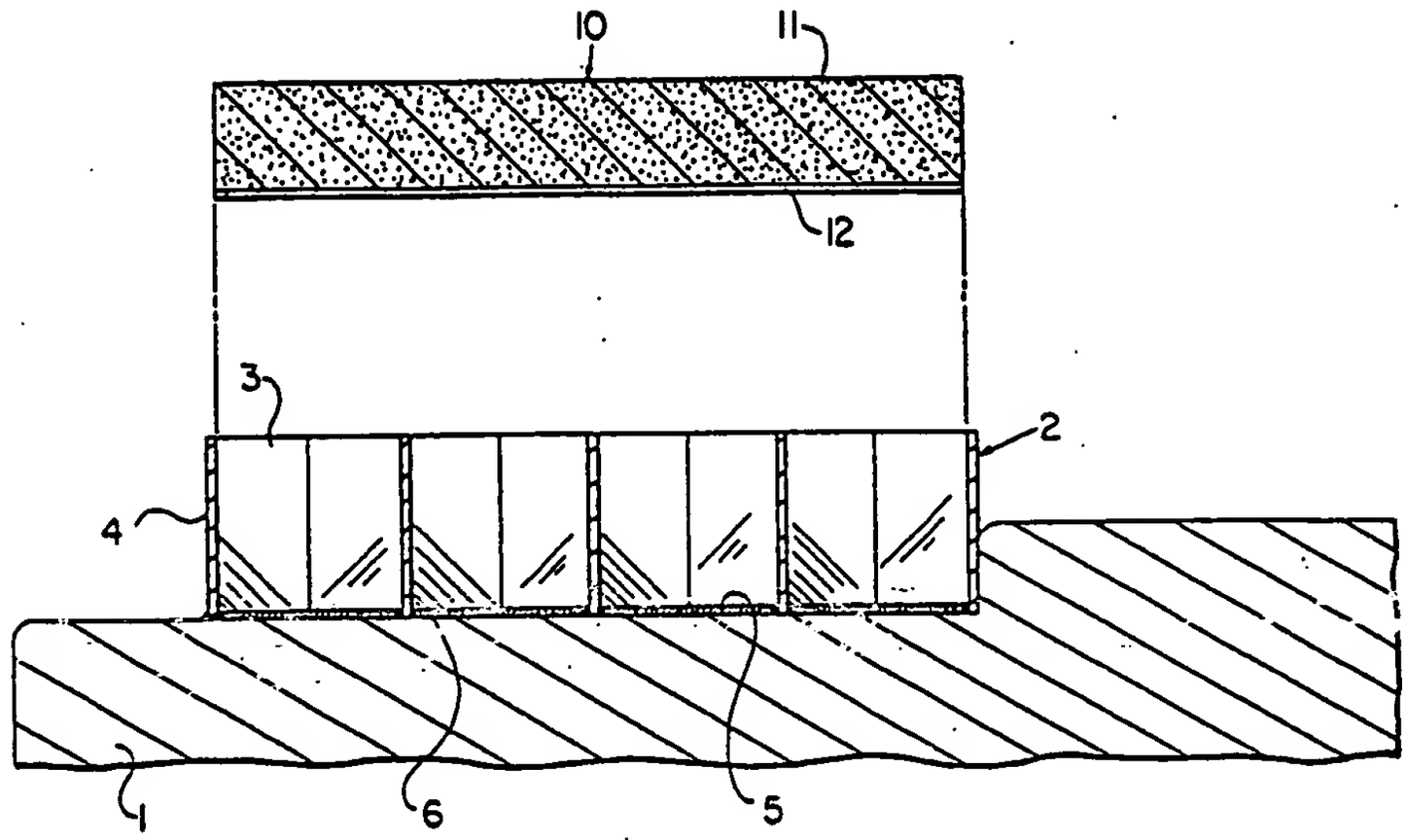


FIG. 1

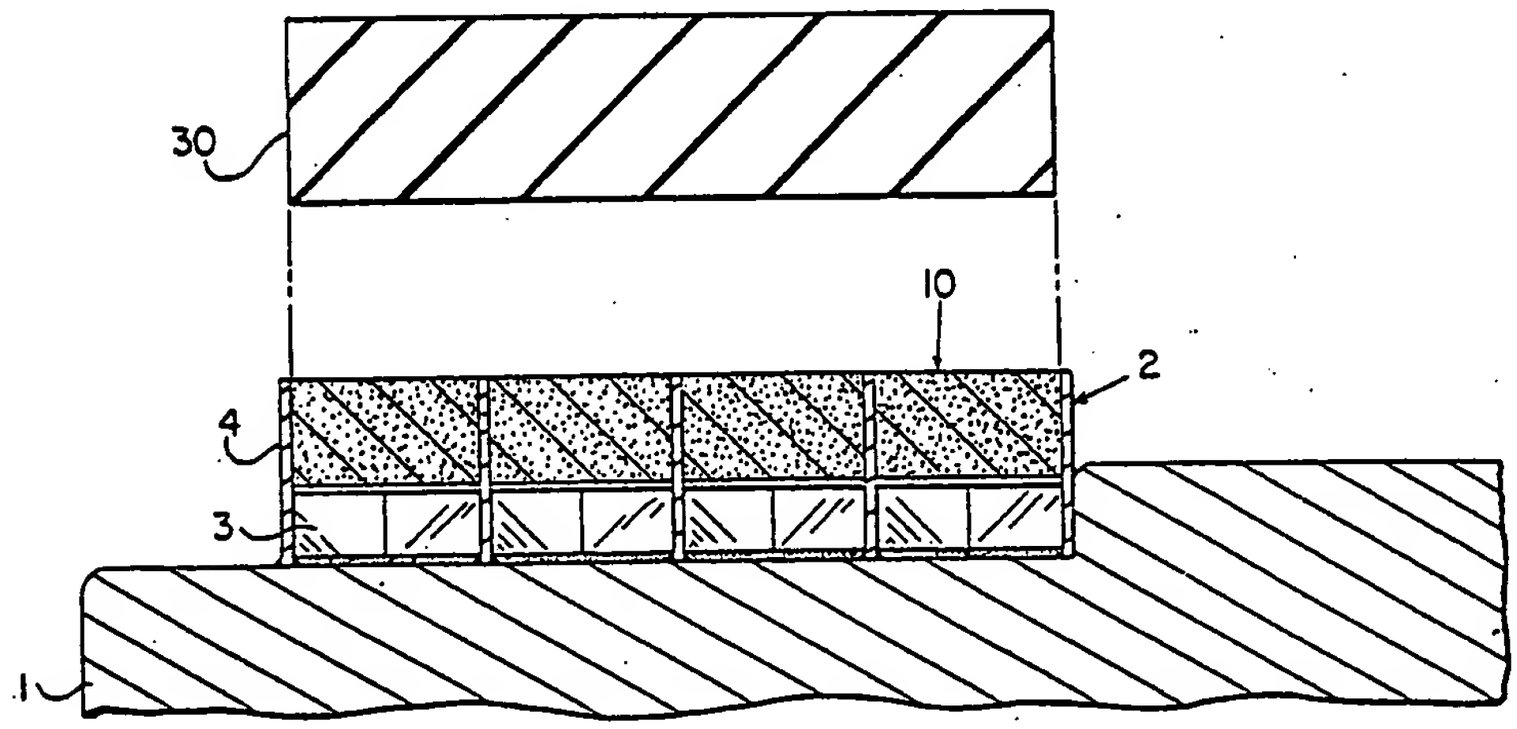


FIG. 2

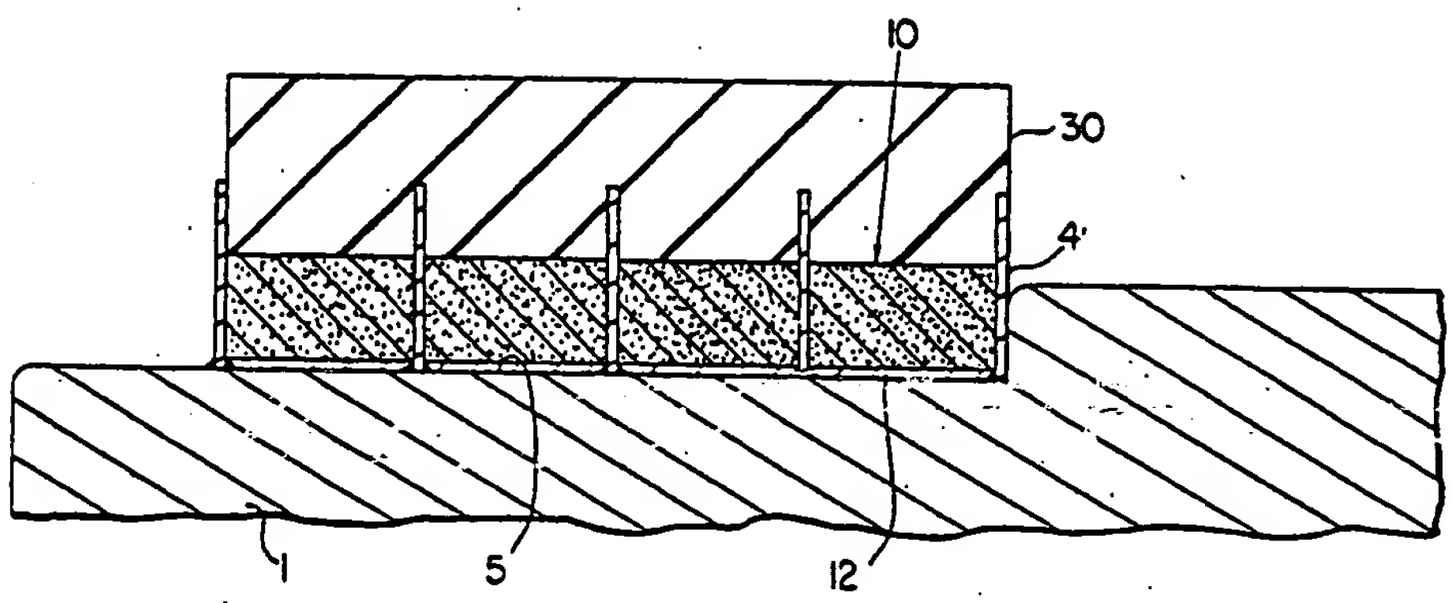


FIG. 3

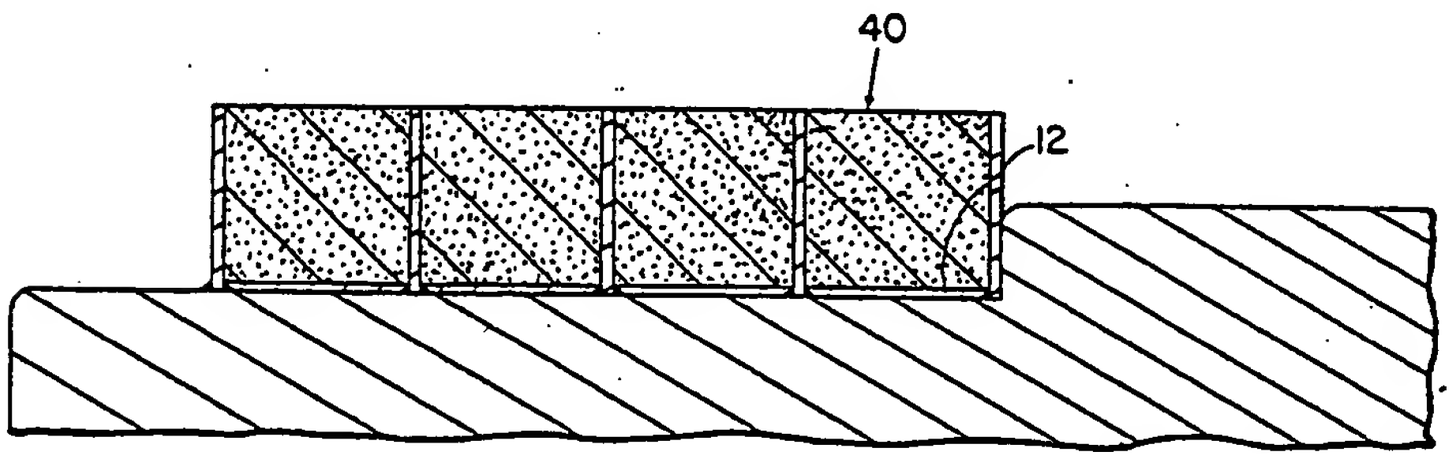


FIG. 4

METHOD FOR APPLYING ABRADABLE MATERIAL TO A HONEYCOMB STRUCTURE AND THE PRODUCT THEREOF

TECHNICAL FIELD

This invention relates to a method for applying abradable material to the cells of a honeycomb structure and to the resulting filled honeycomb.

BACKGROUND ART

It is known in the art to use an abradable material in a rotating machinery application to form a good seal between a moving and a stationary part. This result is obtained by permitting one part to cut a channel or groove into the abradable material. In a gas turbine engine the abradable material is usually placed on the stationary case and the rotating blades cut a groove into the abradable material. In this fashion the changes that may result from thermal growth and blade creep are accommodated. Abradable materials are often located and restrained by being placed in a supporting honeycomb structure.

A typical patent which discloses an abradable material is U.S. Pat. No. 3,879,831. The contents of this patent are incorporated by reference. This patent discloses an abradable material having a total composition of 60–80% Nickel, 2–12% chromium, 1–10% cobalt, 4–20% aluminum and 3–15% inert material such as diatomaceous earth, boron nitride, silica glass, mica, vermiculite asbestos, molybdenum disulfide, graphite, cobalt oxide, cerium oxide and zinc oxide. Up to 3% of a metal selected from the group consisting of yttrium, hafnium and lanthanum may also be added. Table 1 in the patent lists the abradable material components and the preferred particle sizes. Coated diatomaceous earth which is referred to is a product of the Sherrit-Gordon Corporation consisting of diatomaceous earth which has been coated with nickel or an alloy of nickel and chromium.

Similar teachings are found in U.S. Pat. No. 3,817,719 which is also incorporated herein by reference. Such known abradable materials have been applied to honeycomb structures by mixing the dry constituents with a liquid binder such as cellulose nitrate to form a paste and then packing the material into the honeycomb cells. With this method of applying the material to the honeycomb structure various difficulties have been encountered. The uniformity of application is quite variable; consequently, when a complete filling of the cells is desired, it may not be consistently achieved. The results depend to a large extent on the skill of the operator. Further, for those applications which require a partial fill of the honeycomb cells, so that only the bottom half of the cells contain the abradable material, this technique is not capable of producing the desired results.

DISCLOSURE OF INVENTION

An object of this invention is to provide a pliable tape preform consisting of at least one region which contains an substantial amount of a braze material and a second region which is composed primarily of an abradable material. Another object of this invention is to disclose application techniques for using this preform to produce honeycomb structure which is either partially or completely filled with abradable material. Yet another object of this invention is to provide a honeycomb structure which is only partially filled with abradable materials. Other features and advantages will be apparent from the specification and claims and from the accompanying drawings which illustrate an embodiment of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a cross section of an abradable tape and a honeycomb structure prior to insertion of the abradable tape.

FIG. 2 shows a honeycomb structure after the abradable tape has been partially inserted.

FIG. 3 shows a honeycomb structure after complete insertion of an abradable tape forming a partially filled honeycomb structure.

FIG. 4 shows a honeycomb structure after complete insertion of an abradable tape forming a completely filled honeycomb structure.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention relates to honeycomb structures which are at least partially filled with an abradable tape and to methods for producing such structures. The honeycomb structure consists of a multiplicity of hexagonal cells which are separated from each other by thin metal cell walls. Each cell is open at one end while the other end abuts a substrate. "Partially filled honeycomb cells", denote a structure having an abradable composition which extends from the substrate upwards in the cell in a uniform fashion but which does not extend to the top of the cell.

Abradable materials are a class of materials characterized by a high degree of porosity, oxidation resistance, low thermal conductivity and the ability to be cleanly abraded away in a localized area. Typical of such materials are those described in U.S. Pat. Nos. 3,879,831 and 3,817,719. The exact abradable material used is a matter of choice and depends on the particular applications.

Braze materials are a class of relatively low melting point materials often based on nickel or gold with additions of various melting point depressants. The particular braze material used will depend in part on the abradable material and the substrate composition.

The present invention employs a pliable composite tape preform consisting of a thin layer which contains a substantial quantity of a metallic braze material and a thinner layer comprised of the abradable material. The composition tape may be produced using the teachings of U.S. Pat. No. 3,293,072 which is incorporated herein by reference. This patent shows how a tape preform may be produced using a removable carrier film as a substrate and employing an organic polymer such as polyvinyl alcohol or polymethacrylates along with a smaller amount of a volatile plasticizer such as sucrose-acetate isobutyrate, dibutylphthalate or diethyl-oxalate, for use with the polymethacrylate binders, and glycerine for use with the polyvinyl alcohol binders. The powder material is formed into a slurry with the binder, plasticizer and acetone, as solvent, applied as a thin layer to the removable substrate and then heated to remove the solvent.

The present invention will be better understood through reference to the illustrative figures which accompany the specification. FIG. 1 is a cross-sectional view of the honeycomb structure and the tape configured abradable material prior to insertion of the abrad-

able material into the honeycomb. In the figure the honeycomb structure is supported on a substrate 1 and is typically attached thereto by brazing. The honeycomb structure 2 consists of a continuation of hexagonal cells 3 which are defined by thin metal walls 4. The cells 3 are opened at the top and closed at the bottom by the substrate surface 5. The honeycomb structure 2 is joined to the substrate 1 by brazing at the junction between the cell walls 4 and the substrate surface 5. This braze junction appears in FIG. 1 but is deleted in subsequent figures for clarity. Above this substrate cell structure is shown a tape 10 which consists of the abradable portion 11 and the braze portion 12. As previously indicated, this tape is somewhat flexible and pliable as a consequence of the retained binder and plasticizer which will be removed subsequent to installation of the tape-abradable in the honeycomb structure.

FIG. 2 shows the same components as shown in FIG. 1 after the tape-abradable material has been partially inserted into the honeycomb structure. Also shown in FIG. 2 is a rubber strip 30 whose purpose is to insert and locate the composite abradable tape into the honeycomb structure. In FIG. 2 the composite tape 10 has been forced into the honeycomb cell structure 2 and the cell walls 4 of the honeycomb structure have cut the abradable composite tape cutting the tape into hexagonal pieces which closely conform to the honeycomb cells. Insertion of the composite abradable tape into the honeycomb cell structure can be accomplished by using a flat plate or roller to force the material down into the individual honeycomb cells. The insertion tool used, whether a plate or roller should preferably have some resilience so as to ensure complete insertion of the tape into the cell structure and to minimize the possibility of damaging the individual cell walls 4 by the application of excessive force. The rubber strip 30 is used to completely insert the composite tape abradable material into the honeycomb cells and to ensure that the abradable material is firmly seated at the bottom of the individual cell segments. This is shown in FIG. 3. During the insertion process the rubber strip 30 is itself cut by the cell walls 4 as was the abradable tape during its initial insertion. An isostatic force is applied to the abradable material by the rubber strip 30 which ensures that the abradable material is firmly seated at the bottom of the cell structure so that the braze layer 12 at the bottom of the abradable tape 10 makes good contact with the surface 5 of the substrate 1. This good contact is necessary to ensure that a good braze joint is formed upon subsequent heating. Following the complete insertion of the composite abradable tape into the cell structure using the rubber strip, the strip 30 is then removed leaving the composite abradable material in the cell structure. If the rubber strip is not completely removed it will be decomposed during the heating which is performed to remove the binder and plasticizer and the heating which is necessary to form the braze joint between the braze layer 12 and the substrate surface 5.

Certain properties are necessary if the rubber material which is used to form the strip 30 is to properly perform its task of forcing the composite abradable tape down into the honeycomb cells. The material must be pliable and compressible to a limited extent so that it can conform to any irregularities of composite tape thickness which may occur. Most importantly the rubber material must have a relatively low shear strength so that the honeycomb cell walls will easily and accurately cut their way into the rubber material. Adequate results have been obtained with a blend of approximately 50% glass micro-spheres and room temperature vulcanizing rubber (RTV) appropriately cured.

The following description of a specific process is intended to illustrate the invention but is not intended to limit the invention. It was desired to fill a honeycomb structure having the cells of $\frac{1}{8}$ inch in size which were about $\frac{1}{8}$ inch deep. The intended filler material was that material described in U.S. Pat. No. 3,879,831. A composition consisting of 30% by weight of the nickel chromium alloy (80% nickel-20% chromium) having a particle size of minus 230 mesh and 15% by weight of a cobalt-aluminum-yttrium alloy (30% cobalt, 69% aluminum, 1% yttrium) having a particle size of minus 325 mesh and 55% by weight of nickel coated diatomaceous earth (85% nickel, 15% diatomaceous earth) was mixed and throughly blended in the dry state. This mixture represents the components which were to form the abradable material. A braze composition known as AMS 4778 (92% nickel, 3% boron, 4.5% silicon) was provided for use in bonding the abradable material to the substrate. The braze material was provided as a powder of minus 325 mesh size. Two tapes were formed according to the process described in U.S. Pat. No. 3,293,072. One tape was comprised of 75% by weight of the previously described abradable mixture and 25% by weight of the braze material. The thickness of this tape was less than 10 mils. The second tape was comprised completely of the abradable material and had a thickness of 40 mils. These two tapes were pressed together while they were still in a sticky condition and adhered to each other as a consequence of the liquid binder which was present in each tape. This abradable tape was placed over a honeycomb structure with the braze rich layer facing the honeycomb structure and was pressed into the honeycomb structure using a roller. A strip of the previously described rubber material was then placed over the partially filled honeycomb and the roller was then used to force this rubber material into the cells and consequently force the abradable tape material down to the bottom of the honeycomb cells. The rubber strip was removed and the partially filled honeycomb material was then baked at a temperature of about 1200° F. for a period of about 30 minutes to decompose and evaporate or sublimate the binder and plasticizer and was then heated at a higher temperature of about 1850° and 1950° F. for about 5 hours to melt the braze material and cause the braze material to bond to the substrate surface.

FIG. 4 shows another embodiment of the invention in which a tape of the same composition as previously described is used to completely fill a honeycomb structure. In this situation the tape has a thickness which is substantially equal to the height of the honeycomb cell structure and the tape is forced into the honeycomb cell structure using the previously described roller or flat pressing plate. In this situation the tape structure is used to ensure a uniform density of abradable material in each cell structure and to assure that each cell structure has a thin uniform layer of braze material at the bottom of the cell.

It should be understood that the invention is not limited to the particular embodiments shown and described herein, but that various changes and modifications may be made without departing from the spirit and scope of this novel concept as defined by the following claims.

I claim:

1. A method for filling a honeycomb structure comprised of a plurality of cells having a predetermined depth with an abradable material including the steps of:

a. providing a composite abradable preform consisting of a layer of powdered material containing a substantial amount of braze alloy, a second layer joined to the first layer comprising a powdered abradable composition, both of said layers also containing a binder and a plasticizer and being flexible and compliant said preform having a thickness which is less than the depth of the honeycomb cells;

b. placing said preform on the honeycomb structure to be filled with the braze containing surface adjacent the honeycomb;

c. forcing the preform into the cells and using a disposable pliable material to force the preform into the cells braze containing surface contacts the bottom of the honeycomb cells heating the filled honeycomb to remove the binder and plasticizer and further heating to melt the braze material so as to bond the abradable material to the honeycomb structure.

* * * * *

United States Patent [19]

Ackermann

[11] **4,218,066**

[45] **Aug. 19, 1980**

[54] **ROTARY SEAL**

[75] Inventor: **William Ackermann, East Hartford, Conn.**

[73] Assignee: **United Technologies Corporation, Hartford, Conn.**

[21] Appl. No.: **669,424**

[22] Filed: **Mar. 23, 1976**

[51] **Int. Cl.**[3] **F16J 15/44**

[52] **U.S. Cl.** ..... **277/53; 277/215; 415/172 A; 415/174**

[58] **Field of Search** ..... **277/53, 215, DIG. 6, 277/96 R, 96 B, 55, 74, DIG. 1; 415/174, 172 A**

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,963,268	12/1960	Smile et al.	277/53
3,146,992	9/1964	Farrell	415/174
3,339,933	9/1967	Foster	277/53
3,365,172	1/1968	McDonough et al.	277/53
3,603,599	9/1971	Laird	415/174
3,719,365	3/1973	Emmerson et al.	277/53
3,728,039	4/1973	Plemmons et al.	415/174

FOREIGN PATENT DOCUMENTS

855040	11/1960	United Kingdom	277/DIG. 1

Primary Examiner—Richard E. Aegerter
Attorney, Agent, or Firm—Robert C. Walker

[57] **ABSTRACT**

Apparatus for impeding the leakage of a gaseous medium between the rotating and stationary components of a machine is disclosed. Various construction details which are specifically adapted for use in gas turbine engines are developed. Wide channel type sealing techniques are discussed in combination with honeycomb facing materials.

16 Claims, 5 Drawing Figures

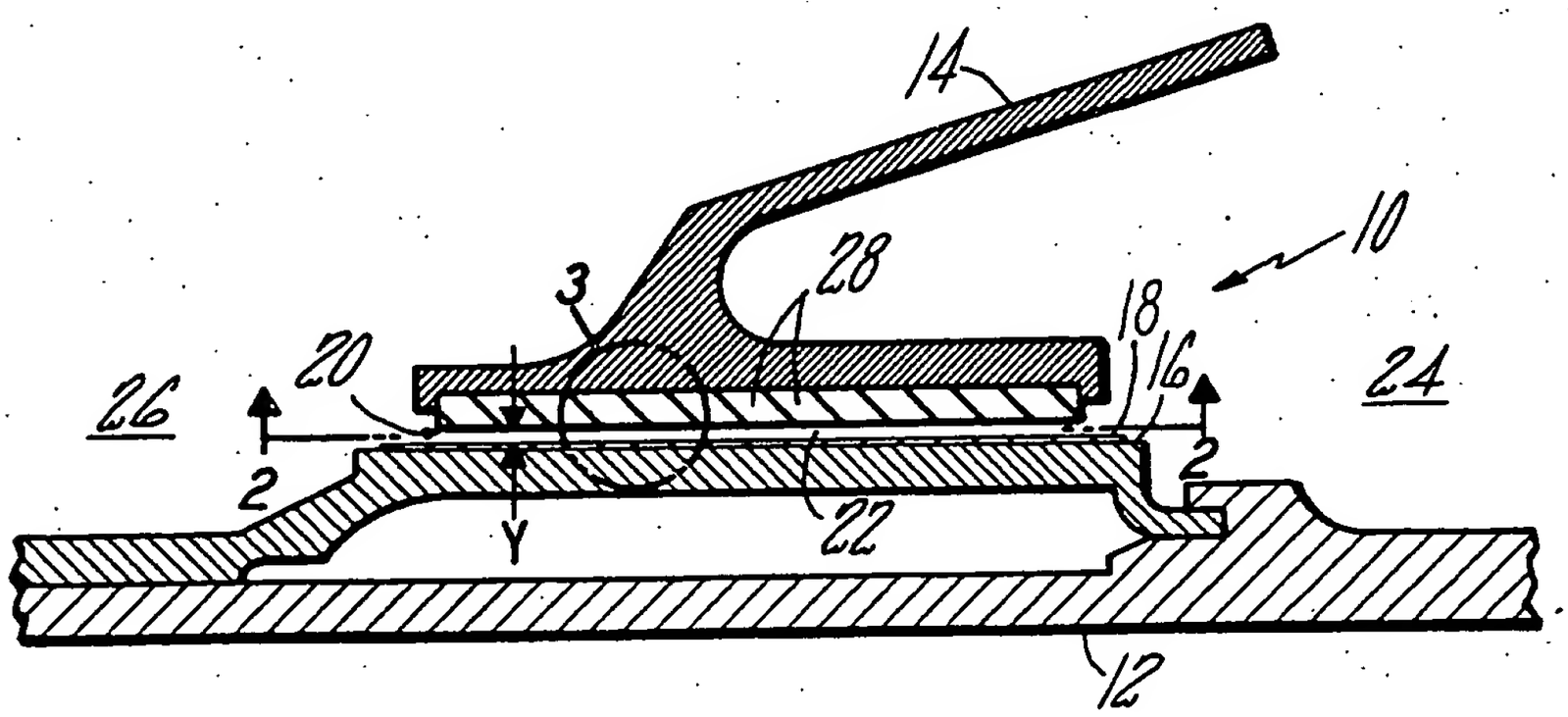


FIG. 1

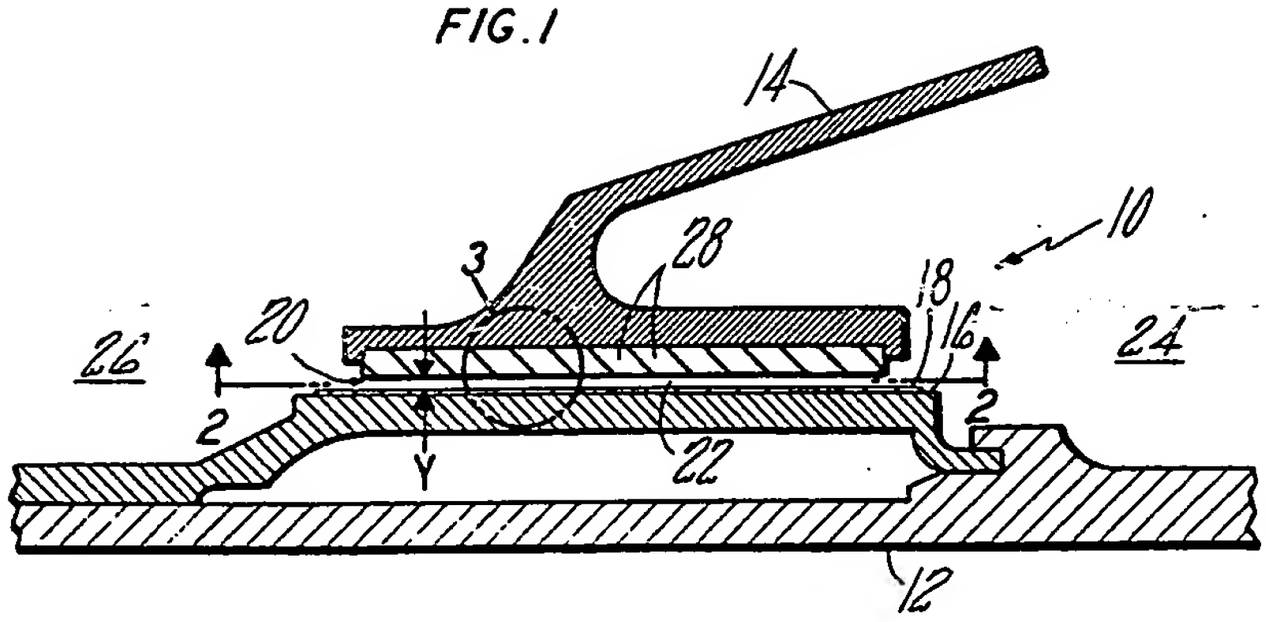


FIG. 2

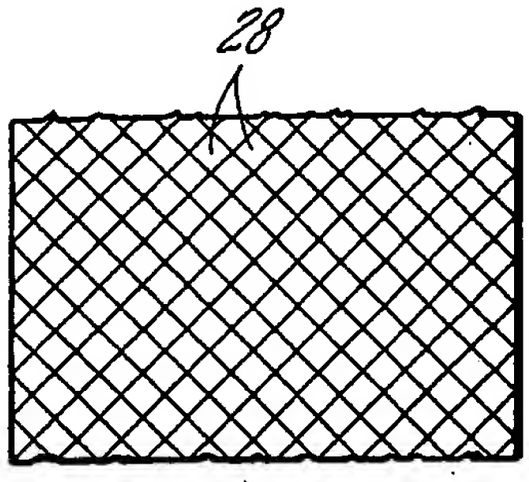


FIG. 2A

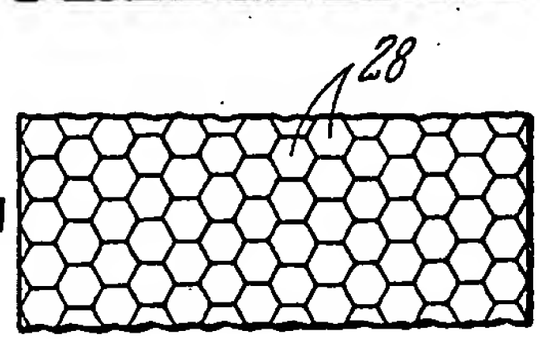


FIG. 3

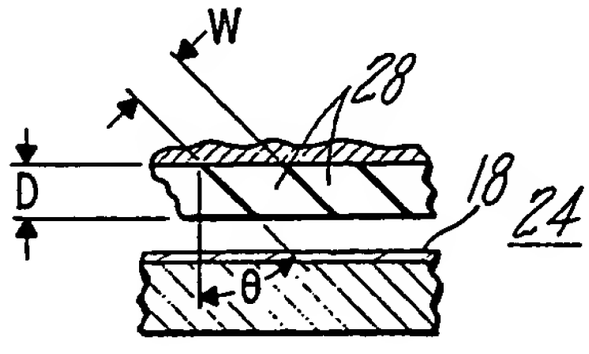
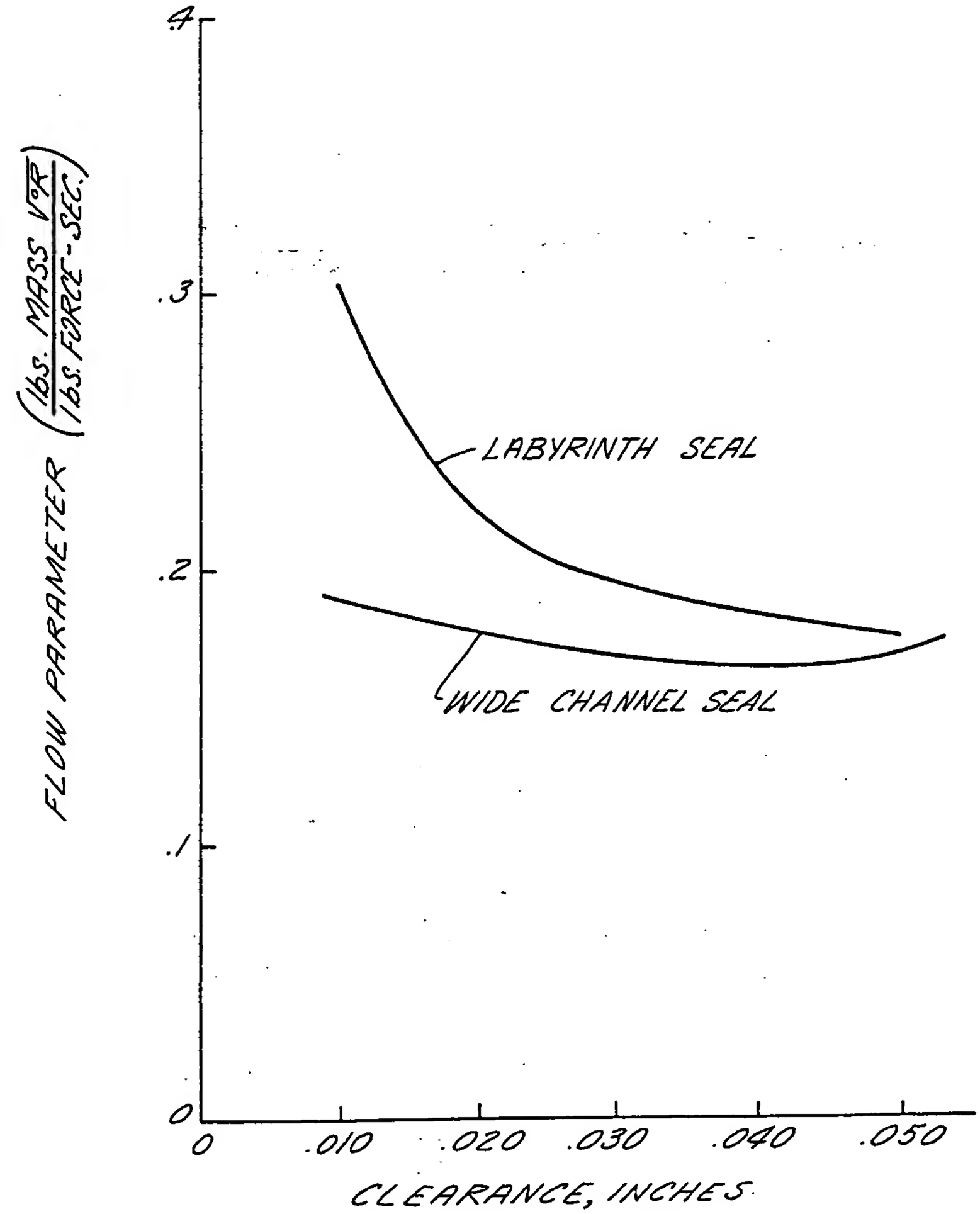


FIG. 4


FLOW PARAMETER (lbs. MASS / lbs. FORCE-SEC. / IN)
.4
.3
.2
.1
0
LABYRINTH SEAL
WIDE CHANNEL SEAL
0
.010
.020
.030
.040
.050
CLEARANCE, INCHES

ROTARY SEAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to rotary machines and particularly to wide channel type seals between the rotating and stationary components of a machine.

2. Description of the Prior Art

Rotary seals are conventionally disposed between the rotating and stationary components of a rotary machine to impede the leakage of a fluid medium therebetween. Labyrinth seals are widely used with gaseous mediums to reduce the kinetic energy of the leakage fluid by throttling and expanding the medium. Labyrinth seals are formed of a sealing surface or land on one component and a restrictive ring on an opposing component wherein the ring projects into close proximity with the land. A plurality of restrictive rings are commonly required in series to effect sufficient energy dissipation.

In gas turbine engines labyrinth seals are typically used to prevent the excessive leakage of air into the bearing compartments and to prevent the excessive leakage of air externally of the working medium flow path from one engine stage to another. One construction for sealing between adjacent stages in the turbine section of an engine is shown in U.S. Pat. No. 3,514,112 to Pettengill entitled "Reduced Clearance Seal Construction." A plurality of restrictive rings in Pettengill project toward corresponding sealing surfaces. A throttle aperture is formed between each ring and its corresponding sealing surface. An expansion chamber is formed between each pair of adjacent rings. Air leaking through the first throttle aperture flows through the downstream chambers and apertures to establish a stable pressure differential across each ring of the labyrinth.

Labyrinth sealing is an effective technique for impeding the flow of a gaseous medium from a region of higher pressure in a gas turbine engine to a region of lower pressure at moderate clearance levels between relatively rotating components. Where a lesser clearance can be provided a second type of rotary seal, a "wide channel seal," is more effective than the labyrinth seal at an equivalent clearance. A wide channel seal is formed of two concentric cylindrical lands, one integrally mounted with the rotating component and one integrally mounted with the stationary component. The lands are closely spaced in opposing relationship to restrict the flow of the fluid medium between the two components by imposing frictional flow losses on the medium. One of the lands conventionally is covered with a honeycomb material to greatly increase flow turbulence within the channel.

Wide channel seals are less costly to manufacture and offer a weight saving when compared to labyrinth seals. Significant technical effort is being directed, therefore, to extending the clearance range of effective wide channel seals to make such seals suitable for use in engines requiring seal clearances of varied dimensions.

SUMMARY OF THE INVENTION

A primary aim of the present invention is to minimize the leakage of a fluid medium between the rotating and stationary elements of a rotary machine. Aerodynamic resistance to flow in a seal which is effective over a varied clearance dimension is sought. In one aspect of the invention, a specific object is to provide a seal structure having low resistance to abrasion while maintaining preferred structural characteristics.

According to the present invention, a wide channel type seal between two components adapted for relative rotations is formed of a honeycomb cylindrical surface on one component and a relatively smooth cylindrical surface on the opposing component wherein the cells of the honeycomb surface are canted in the upstream direction with respect to the flow across the seal.

In accordance with one embodiment of the invention, the cylindrical surface is coated with an abrasive material to encourage abrasion without excessive local heating of the opposing honeycomb material.

A primary feature of the present invention is the wide channel type seal which is disposed between the rotating and stationary components of a rotary machine. One of the channel forming members is fabricated from a honeycomb type material in which the cells of the honeycomb are canted in the upstream direction with respect to leakage flow across the seal. In one embodiment, the opposing channel forming member is coated with an abrasive material.

A principal advantage of the present invention is improved resistance to leakage flow. Destructive interference between the relatively rotating components is avoided through the use of the low density, honeycomb material. Improved resistance to cellular deformation is found in at least one embodiment incorporating an abrasive coating on the relatively smooth, cylindrical surface. Tight clearances are employable without fear of cellular deformation as the honeycomb material abrades. Increased aerodynamic resistance to flow is imposed against the leakage medium as strong local vortices are generated in the canted cells.

The foregoing, and other objects, features and advantages of the present invention will become more apparent in the light of the following detailed description of the preferred embodiment thereof as shown in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partial sectional view taken through a wide channel seal constructed in accordance with the present invention;

FIG. 2 is a directional view taken along the line 2—2 as shown in FIG. 1;

FIG. 2A is a directional view of an alternate cell structure taken along the line 2—2 as shown;

FIG. 3 is an enlarged view of the area 3 as shown in FIG. 1; and

FIG. 4 is a graph showing comparative leakage characteristics between a labyrinth type seal and a wide channel type seal constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A wide channel type seal 10 is shown in FIG. 1 between the relatively rotating components of a rotary machine. The seal is formed between a rotating or rotor assembly 12 and a stationary or stator assembly 14. A cylindrical seal land 16 having an abrasive coating 18 affixed to the surface thereof is supported by the rotor 12. A cylindrical honeycomb strip 20 is attached to the stator 14 and radially opposes the coated surface of the land 16 to form an annular channel 22 therebetween. The seal separates a region of higher pressure 24 from a

region of lower pressure 26. The honeycomb strip comprises a multiplicity of individual cells 28 which are open to the channel 22. The cells are canted in the direction of the higher pressure region 24 to an angle θ and are constructed with a cell width W as is shown in FIG. 3.

During the operation of a machine in which the wide channel seal 10 is incorporated, the pressure differential between the higher pressure region 24 and the lower pressure region 26 causes the fluid in the higher pressure region to flow through the annular channel 22. Strong local vortices are generated within each cell 28 as the fluid passes the cell openings. The vortices extend into the channel 22 to cause circumferential deflection of the flowing fluid. The circumferential deflection imposes a substantial increase in the pressure drop across the channel when compared to a seal construction confining pure axial flow.

The cells are canted into an angle θ in the direction of the higher pressure region 24. Canting the cells encourages the formation of the vortices by orienting the cell walls at an angle to the approaching flow. In one construction an angle θ of approximately forty-five degrees (45°) was found to be particularly effective although a substantial deviation on either side of forty-five degrees (45°) is expected to produce improved resistance to flow when compared to wide channel honeycomb seal structures having cells which are oriented perpendicularly to the flow through the channel.

The honeycomb cells shown in the drawing have a diamond shaped cross section as viewed in FIG. 2 from the axis of the seal. The diamond shape is representative of cell patterns in which the vortex generating cavities are staggered with respect to the flow through the channel. The staggered cell pattern increases the impending effect of each vortice over the effect that is obtainable with axially aligned vortices. Other staggered geometrics such as one employing the hexagonal cross section of FIG. 2A are correspondingly effective. The concepts disclosed herein, however, are not exclusively limited to staggered geometrics.

Tight clearance control between the relatively rotating components of a machine is obtainable with apparatus constructed in accordance with the concepts taught herein. The honeycomb structure has a very low density and is abradable during operation of the machine. The initial channel width Y, as shown in FIG. 1, is set at less than the expected relative radial excursion of the rotor 12 so that at the condition of maximum excursion the seal land 16 abrades the outer portion of the honeycomb strip 20 to provide a zero (0) clearance at maximum rotor excursion.

Damage to the honeycomb structure during interference between the strip 20 and the land 16 is minimized on one construction wherein the abrasive coating 18 is affixed to the inwardly facing surface of the land 16. The abrasive coating severs the interfering honeycomb from the remaining structure to avoid the deformation of material into the cell openings and the resultant decrease in the strength of the vortices generated by the deformed structure. Silicon carbide and aluminum oxide have been found to be effective abrasive materials, although, other coatings having similar qualities are expected to produce comparable results.

The depth D of the individual cells is optimized for each cell width W to provide a structure which generates strong local vortices. For a cell width of one quarter (¼) of an inch, a depth of approximately one hundred thousandths (0.100) of an inch is effective. For a cell width of one eighth (⅛) of an inch, a depth of approximately sixty thousandths (0.060) of an inch is effective.

The FIG. 4 graph demonstrates the decreased leakage rate of a honeycomb wide channel type seal having cells canted in accordance with the present invention when compared to a honeycomb land labyrinth type seal having four restrictive rings. Both seals have an overall axial length of two (2) inches and separate regions having a pressure ratio of 1.5 therebetween. As is discernible from the graph, the wide channel seal exhibits dramatically improved sealing effectiveness at clearances less than fifty thousandths (0.050) of an inch.

Although the invention has been shown and described with respect to a preferred embodiment thereof, it should be understood by those skilled in the art that various changes and omissions in the form and detail thereof may be made therein without departing from the spirit and the scope of the invention.

Having thus described a typical embodiment of my invention, that which I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination with the rotor and stator assemblies of a rotary machine, a seal structure for impeding the leakage of a gaseous medium between said assemblies wherein said structure comprises a cylindrical seal land extending from the rotor assembly and a cylindrical honeycomb faced land extending from the stator assembly into close proximity with the seal land of the rotor assembly forming, therewith, an annular channel separating the rotor and stator assemblies of the machine, said honeycomb material having a multiplicity of cells which are canted in the upstream direction with respect to the anticipated direction of flow through the channel during operation of the machine to encourage the generation of local vortices within the channel for impeding said leakage of gaseous medium between the rotor and stator assemblies.

2. The invention according to claim 1 wherein the cells of the honeycomb material are canted to an angle of forty-five degrees (45°) with respect to said anticipated direction of flow.

3. The invention according to claim 1 wherein said seal land of the rotor assembly has a relatively smooth cylindrical surface.

4. The invention according to claim 1 wherein said formed annular channel has an axial length of approximately two inches.

5. The invention according to claim 1 wherein said cells of the honeycomb material have a depth of approximately one hundred thousandths (0.100) of an inch and a cell width of approximately two hundred fifty thousandths (0.250) of an inch.

6. The invention according to claim 1 wherein said cells of the honeycomb material have a depth of approximately sixty thousandths (0.060) of an inch and a cell width of approximately one hundred twenty-five thousandths (0.125) of an inch.

7. The invention according to claim 1 wherein said cells of the honeycomb material have a diamond shape.

8. The invention according to claim 1 wherein said cells of the honeycomb material have a hexagonal shape.

9. The invention according to claim 1 wherein said seal land has affixed thereto an abrasive coating which is adapted to wear the honeycomb land upon interference rather than deform the honeycomb cellular structure.

10. The invention according to claim 9 wherein said abrasive coating includes silicon carbide.

11. The invention according to claim 9 wherein said abrasive coating includes aluminum oxide.

12. A seal structure for impeding the leakage of a gaseous medium within a turbine engine from a region of higher pressure to a region of lower pressure, comprising:

a first cylindrical seal land; and

a second cylindrical seal land which radially opposes said first land forming an annular channel therebetween which axially separates the region of higher pressure from the region of lower pressure, and wherein the second land has affixed thereto a honeycomb material so oriented as to cant the cells of the honeycomb material in the direction of the higher pressure region.

13. The invention according to claim 12 wherein the cells of the honeycomb material have a diamond shaped cross section including a cell width of approximately one quarter (¼) of an inch and a cell depth of approximately one tenth (1/10) of an inch and wherein the cells are canted to an angle of approximately forty-five degrees (45°) in the direction of the higher pressure region.

14. The invention according to claim 12 wherein said seal land has affixed thereto an abrasive coating which is adapted to wear the honeycomb land upon interference rather than deform the honeycomb cellular structure.

15. The invention according to claim 14 wherein said abrasive coating includes silicon carbide.

16. The invention according to claim 14 wherein said abrasive coating includes aluminum oxide.

* * * * *

9-25-01

AF/3724

Please type a plus sign (+) inside this box → [+]

PTO/SB/21 (08-00)
Approved for use through 10/31/2002. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	08/327,744
Filing Date	October 24, 1994
First Named Inventor	M. ANTHONY STONE, ET AL.
Group Art Unit	3724
Examiner Name	C. Goodman
Total Number of Pages in This Submission: 66	Attorney Docket Number: 3309P-65

ENCLOSURES *(check all that apply)*

- [✔] Fee Transmittal Form
  - [✔] Fee Attached
- [ ] Amendment / Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Assignment Papers *(for an Application)*
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) _____
- [ ] After Allowance Communication to Group
- [ ] Appeal Communication to Board of Appeals and Interferences
- [✔] Appeal Communication to Group (*Appeal Notice, Brief, Reply Brief*)
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (*please identify below*):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Susan C. Oygard, Esq. McCormick, Paulding & Huber LLP
Signature	Susan Oygard
Date	1/25/01

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as ~~first class~~ express mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231 on this date: 1/25/01

Typed or printed name	Mary E. Dionne		
Signature		Date	1/25/01

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

PTO/SB/17 (09-00)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

FEE TRANSMITTAL for FY 2001

Patent fees are subject to annual revision.

TOTAL AMOUNT OF PAYMENT	($) 310.00

Complete If Known	
Application Number	08/327,744
Filing Date	October 24, 1994
First Named Inventor	M. ANTHONY STONE, ET AL.
Examiner Name	C. Goodman
Group Art Unit	3724
Attorney Docket No.	3309P-65

METHOD OF PAYMENT

1. ☑ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

Deposit Account Number: 13-0235

Deposit Account Name: McCormick, Paulding & Huber LLP

☑ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR 1.27

2. ☑ **Payment Enclosed:**

☑ Check ☐ Credit card ☐ Money Order ☐ Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility filing fee	
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 00

2. EXTRA CLAIM FEES

		Extra Claims		Fee from below	Fee Paid
Total Claims		-20** =		X	=
Independent Claims		- 3** =		X	=
Multiple Dependent					=

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 00

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	390	216	195	Extension for reply within second month	
117	890	217	445	Extension for reply within third month	
118	1,390	218	695	Extension for reply within fourth month	
128	1,890	228	945	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	310.00
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,240	241	620	Petition to revive - unintentional	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	710	246	355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR § 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) _____

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 310.00

SUBMITTED BY				Complete (if applicable)	
Name (Print/Type)	Susan C. Oygard, Esq.	Registration No. (Attorney/Agent)	42,969	Telephone	860.549.5290
Signature	Susan Oygard			Date	January 25, 2001

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.